NATURAL HISTORY

of { NUTRITION, LIFE, and VOLUNTARY MOTION.

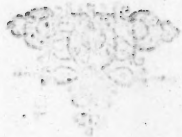
Containing
All the *NEW DISCOVERIES*
of *ANATOMISTS*, and most probable
Opinions of *PHYSICIANS*,

Concerning the
OECONOMIE OF HUMAN NATURE;

Methodically delivered in
EXERCITATIONS PHYSICO-ANATOMICAL.

By WALT. CHARLTON: *M. D.*

LONDON,
Printed for *Henry Herringman*, and are to be sold at his shop at the *Anchor* in the lower walk in the new *Exchange*. 1659.



TO THE
RIGHT HONORABLE
THOMAS, VICOUNT
FAUCONBERGE.

MY LORD,

IT *was the ſaying of a learned, wiſe, and great Man, of our Nation, that* Books of Uſe ought to have no Patron, but Truth and Reaſon; *And whether or no I have obſerved this* Rule, *in devoting this* Book *to* your Lordſhip's Patronage, *will not be much diſputed by Any, who have the Hap-*

pinesse and Honour to Know you well. For, whoever understands your general insight into all Kinds of Learning, your exact Judgment in distinguishing Truths from Falshoods, however subtily concealed and plausibly delivered, and your strict Reasonings in all Arguments offered to your Consideration; doth need no other proofs to convince him, that, if You are not Truth and Reason it selfe Animated, *yet (at least) you have them in you, in so eminent a degree, that it can be no Flattery to say, You are therein a* Grand Exemplar *to Others : nor will the most Scrupulous refuse to embrace, as Authentique and Current, whatever Position hath once received the stamp of your Assent and Approbation. So singular a Felicity it is, to render* Nobility *more illustrious with* Learning; *to have long cultivated a fertil* Mind, *with select* Precepts, *and usefull* Observations *of Men and Manners ; and alwayes to make mature* Deliberation *the Harbinger to* Belief, *as well as to* Action.

Besides, the Argument *of this Discourse*

course, which now humbly seeks your L^ps. *Countenance, is much more proper and fit for Your Cognizance, than vulgar Eyes perhaps may judge, when they first glance upon the* Title of it. *For* (*to omit, that it leads to the most excellent of all Human Knowledges; the Knowledge of* Ones self, *which is the ground-work of* Civil Prudence) *it explaineth the most probable* Oeconomy of Nature *in perfect* Animals; *and especially the most perfect and noble of them,* Man: *A piece of Science, certainly, so far from being Unnecessary to a* Statesman, *that I dare affirme,* None can ever attain to any competent proficiency in the Mysteries of State-principles, or the Art of Governing Men, who is not in some measure conversant in the Mysteries of Human Nature, *as well those which concern the* Constitution *and* Fabrique *of the* Body, *as those which belong to the* Inclinations *and* Passions *of the* Mind. *And, the* Reason *hereof is obvious and plain; since the* Maximes *of sound* Policy *ought to be*

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derived from the Lawes *of* Nature, *at least by way of Analogie and Imitation: & the best way to understand, how to preserve Men in* Societies, *is to observe, How* Nature *at first produceth, and afterward conserveth them in their* single Persons, *or* individual Beings. *Certainly, My Lord, the highest pitch, to which* Human Wisdome *can aspire, is, to imitate the works of* God *in his Creatures: and the most perfect* Model *or* Form *of Government, is that, which comes neerest to the Idea of the* Divine Constitutions, *either in the larger Volume of the* Universe, *or in the exact Abridgment of it, the* Body of Man. *This made* Pythagoras *call Man, the* Measure of all things. *This makes the greatest* Politicians *so frequently consult the oraculous Aphorisms of our perpetual Dictator,* Hippocrates; *and transferre His Rules of curing* Diseales *of the* Body, *to the composing* Disorders, *and rectifying* Distempers *in the* State. *This* Menenius Agrippa *found a happy truth; when He, in a moment, appeased the seditious and mu-*

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tinous Commons of Rome, only by a speech, wherein He compared the several Members *requisite in a well-ordered Commonwealth, to those in the Body of Man; and shewed the* Offices *of* Those, *to be as necessary as the* Functions *of* These. *And, this that incomparable Sophy, the* Lord St. Alban, *seems to have reflected upon, when He said,* It was without president, that any Government had been disastrous in the hands of Learned Governours; *and doubted not to call those,* Empirique *States-men, who are ignorant in* Natural Philosophy. *I could, My Lord, exspatiate in this noble and ample Theme, and permit my* Pen *to run into a* Parallel *betwixt the several* Parts *in a Body* Politique, *and those in the Body* Natural; *and demonstrate the neer* Affinity *and* Correspondence *of them, in their respective* Uses, Actions, *and wayes of subministring to the Health and Conservation of the whole: but that I here speak to a* Person, *to whom such speculations are so familiar, that I should dero-*

gate

gate from the Vastnesse of his Parts, *to imagine it needfull for me onely to put Him in Mind of them, or (indeed) of any thing else suitable to that place of Eminency, and Condition of Dignity, to which his Virtues have advanced Him.*

Now, *My Lord, these my* Exercitations *being thus, in a* Twofold Respect, *capable of your Lordships Favour; their* Ambition *in seeking to acquire to themselves more of Value and esteem, from the Knowing and Ingenious part of Mankind in our English World, by carrying your illustrious* Name *in their Front; is not only Excusable, but also* Commendable, *as being grounded on the Law of* Decency, *which forbad them to addresse to any other Sanctuary; and which evinceth, that this their applying themselves to your Lordship, was upon due* Regard, *not upon* Facility.

And, for my Own *part; that I have taken this way of Testifying the extraordinary* Respect *and* Honour *I bare to your* Person *and* Virtues: *this is to be imputed,*

partly

partly to the Humility of my Condition; *which permits me not to be so happy, as to have any better Means, or Opportunity of expressing my Devotion; and partly to my* Gratitude, *for the many singular Favours Your* Generosity *long since conferred upon me, which alwayes urgeth me, in the best manner I am able, to acknowledg my selfe,*

My most Honoured Lord,

Your Lordships

Most humble, and most entirely devoted Servant,

Walt. Charleton.

The

The Stationer to the Reader.

THat you might be acquainted with the Occasion of the Author's writing this discourse, his Design therein, and the Motives that induced Him to consent to the Publication of it; I have obtained leave of him, to Print also this following Epistle of his to that Excellent Person, Dr. Ent, to whose peircing and impartial judgment, he thought fit to submit his own, as well concerning the Verity and weight of what his Papers contained, as concerning the fitnesse of their Constitution to endure the publique air. And this Favour I was the more importunate with him for; both because it might evidence his Modesty, in distrusting his own Exactnesse: and because it might appear, it was not only his Inclination, that brought this Book into my hands, and so into yours. Besides, I was not so improvident of my own Advantage, as not to understand, how much of Reputation the Booke hath acquired to it self, by passing the Examination of a Man, whose Universal Learning, and admirable Perspicacity in things of Nature, have conspired to render him as competent a judge of such Treatises, as the World affords. This I say, not to assure you, that Dr. Ent found nothing in these Papers, from which He thought fit not to dissent; because, the subjects of Philosophers speculations and Enquiries, being usually very obscure in themselves, it is no rarity to meet with Diversity of Opinions among Them, as well as among the Vulgar: but, thus much I dare avouch, that He dissented but in very few points, and those only concerning such difficulties, that are not yet cleerly determined by Anatomical Observations; and that nevertheleße, He pronounced the whole work to have been undertaken upon mature Consideration, and done with singular Care, Industry, and Circumspection. And I doubt not but you also will be of the same Opinion, when you have attentively read the booke; in which confidence I commend it into your hands, being not a little glad of so good an opportunity to manifest my devoir toward the advance of Knowledge, and service of the Publique.

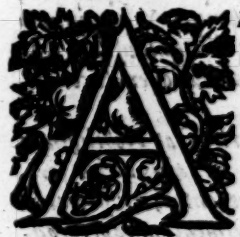
Hen. Herringman.

Clarissimo Atque Ornatissimo Viro.

D. GEORGIO ENT,

M. D. &,

Celeberrimi Medicorum *Londinensium* Collegij, Socio dignissimo.



Nnus jam fermè elapsus est (Præclarissime Vir,) ex quo è Magnatibus *nostris Quidam (insignis quidem* Hippocraticæ *familiæ Fautor, & cujus, in cæteris omnibus quæ ad veram Sapientiam spectant, eruditissimo Animo singularem res etiam* Physicas *altiùs contemplandi avidi-tatem, à juventute usque infuderat Ipsum* Naturæ *Numen) quotidiana, mihique prorsus ineluctabili precum importunitate, à me efflagitabat; ut, sepositis aliquantisper, quibus tunc temporis totus incumbebam, studiis, nupera* Anatomicorum *Inventa, simul cum celebrioribus* Medicorum *super iisdem Sententiis, maximè quæ* Arti *nostræ & luminis & augmenti plurimum attulisse hodie censentur, breviter Sibi, atque ex ordine, enarrarem. Neque enim (ut aiebat) otii tantum à severioribus Reip. negotiis suffurari potuit, quantum satis esset perlegendis omnibus, quæ de re* Anatomicâ *novi quid, supraque Vulgarem Genium sublimis, in se continerent, Recentiorum Voluminibus.*

Ipse

Ipse autem, quò illustris adeò Viri, mihique verè Patroni, imperio, quantum in me esset, obsecundarem; ne tam laudabilem, quâ flagrabat heroïca Mens, in reformatæ Anatomes *mysteria inquirendi sitim, diutiùs inexpletam relinquerem: quam demandare placuit, provinciam in me libenter suscepi. Mox itaque ad Authorum eorum, quorum seu* Industriæ, *seu disquisitionum* Felicitati, *nuperas in Medicorum Scholâ* Novitates *debemus, iteratam lectionem seriò me accinxi; atque ex iisdem denuò quæcunque Mæcenatis mei expectationi satis facere posse judicabam, fideli calamo exscripsi: nec vadimonium datum ante deserui, quàm* Ἀποσπάσματα *simul in unum (qualis de* Oeconomiâ Animali, *juxta recentes in* Anthropographiâ *Hypotheses, ingenuè Philosophantem decere videretur) continuum* Tractatulum *consuissem; adjectis hîc illic quibusdam* Ratiociniis, *quæ ad cæterorum sive elucidationem facerent, sive connexionem.*

Cæterùm, Chartulas haud citiùs perlegerat Nobilissimus Dnus *quin, ipsas, non Sibi modo, sed & aliis utiles fore, generosa quadam* Humanitatis *exsuperantiâ, existimans; ulteriùs adhuc sui in me arbitrii experimentum capere adnixus sit, adque operis* Divulgationem *ardentissimè me solicitaverit. Recusavi sæpius; utpote non ignarus, quàm exigui essent pretii hæ Lucubrationes, apud perspicaciores Sophiæ cultores; quámque nihili sit ista Laudis messis, quæ ex* Rhapsodicâ *Scriptione, utcunque fideli elaboratâque, acquiritur: & quò metipsum meliùs tueri possem, varia in contrarium adduxi argumenta. Dixi nimirum, quæ scripseram, in privatum solummodò Ipsius oblectamentum collecta fuisse, stylique impolitioris stamine contexta; ideóque summè temerarium fore, si extra privatos cancellos in publicum divagari permitterentur: pleraque ex contentis, licet Ipsi forsan novitatis specie arriderent, aliis tamen, maximè*

è Doctiorum

è Doctiorum *censu, jam obsolescere: me demique occurrentibus in operis serie aliquibus* Difficultatibus, *quas vel omninò intactas reliquissent, vel sensu planè diverso explicâssent* Emunctiores) *eâ interdum usum Conjectandi libertate, cujus me deinceps, post secundas cogitationes, forsitan meritò pœniteret. Sed plane frustrà fui: Is enim, concepti semel desiderii pertinax, contra excusationem omnem aures occluserat. Quid agerem igitur? Hinc Viri* Dignitas, *&* Amicitiæ *Sacra premebant; illinc* Tenuitatis *meæ conscientia: Contra hanc peccare, temeritatis esset, atque insolentiæ; nefas autem illa violare. Hôc Dilemmate obsessus, diu anceps sum animi, donec tandem ea conditione inter nos conventum est, ut cordatum aliquem ex Æsculapii Mystis, in rei decisionem, ilicò appellaremus. Acceptâ itaque semel utrinque æquissimâ isthâc lege; pronum erat, Quem è Nostratium Doctissimis in* Arbitrum *seligeremus.*

TE enim, Vir Excellentissime, *quem esse eum omnes meritò agnoscunt, in quo Eruditioni summæ (sine fuco dicam) summus accessit Morum candor, in ingens* Medicinæ *decus,* Nominisque Tui *immortalitatem; Quis aut* Cordatior, *aut* Æquior *poterat nominari in judicem? Tuum itaque penes arbitrium jam est, ut vel securis Musæoli mei tenebris, vel petulantis, inque Eruditorum scripta, supra quàm decet, severioris Vulgi Censuræ, adjudicetur. Hicce, talis qualis est, de Humani Corporis Oeconomiæ,* Discursus: *quem in eum finem ad* E. T. *nunc misi, vacivis horis (saltem nisi molestum nimis fuerit) evolvendum; non opinionem, sed Oraculum habiturus, quicquid super eodem è Delphico tripode responderis. Spero autem interim, antiquam tuam, & toties feliciter à me expertam, in Tui Cultores* Humanitatem, *mihi excusationi suffecturam, quòd sublimiores Tuas, atque in* Artis *nostræ (quam* Dijs *ipsismet adeò cognatam meritò agnoverunt Veteres) Compendium*

dium usque defixas, Contemplationes, nugis meis tam diu interpellare ausus sim: Teque etiam, utut in hac re sim importunus, facile tamen posse exorari, ut amare pergas

Virtutibus Tuis addictissimum

Londini, 12. Junij
M. DC. LVIII.

Gualtrum Charletonum.

Postscriptum.

EST & aliud adhuc, quod ab. E. V. *summoperè rogare velim; nimirum, ut, sicubi à verô aberravero, in viam reducere dignetur; nec Censoriâ, ubicunque videbitur, virgulâ abstineat. Mihi siquidem, exilitatis meæ semper conscio, volupe admodum est, à* Tali *Viro corrigi, docerique,*

——Unum Tritonia Pallas
Quem docuit, multâque insignem reddidit Arte.

Galen.

Galen. in 2. de Motu Musculor. cap. 5.

QUi evidentibus fidem abrogat, sensûs est expers; qui verò de dubiis promptè pronunciat, temerarius est; qui autem, propter obscuritatem, quæ in his inest, quæ etiam clara sunt & manifesta, habet suspecta; de numero eorum est, qui dubitationibus oblectantur. Porrò, qui non modò quæ suspecta habet; verùm etiam quæ clara sunt, propter obscuritatem dubiorum, studet evertere; extremè fatuus est. Ne igitur sponte sensum nobis ipsi adimamus, neque dubitationis æmuli, aut fatui, aut aliud ejusmodi quidvis simus; sed quod tum rectum est, tum modestis Hominibus convenit; quod quidem evidens est, promptè accipiamus; quod autem dubium est, per ocium quæramus. ¶.

Errors of the Presse, Correct thus.

PAge.1,line.20. read *Plastique.*
page.5.line.1,read Aristotleans.
pag. 8.line 2 read *Void.* and line 20. read δεοσιωτη.
page.10. line. 7. read *Homœomerian.*
p. 13. l. 10. read ructus acidus,and l.25 one and the same, &c.
page.15.line 9.read difficultly.
page. 17.line.13 read *Pecquet.*
page,26 line.29.read *Pecquet.*
page.31.line. ult. read,other branches
page 40.line.4 read, its own nature,&c.
page.61.line.13.read,apposition.
page.64.line.4.read,*Venom.*
p. 72. l. 1. r. *Slegelius*,and the same,line.12.
page.77.line penult. read,only thus much.
pag.83.line.18.read,draw themselves,&c.
page.86.line.22.read *Fracastorius.*
page 89.line.29.read lax.
page.95.line.17.read voided.
page. 114. line.7.read *Capsula.*
page. 116. line. 10. read Nerve.
page.157.line.19.read Nerve.
page.190.line.8.read,veins.
page.192.line.ult. read,covered.
page.193.line.17.read *Taylors* Muscle.

OF NVTRITION.

Exercitation the First.

Of Nutrition.

Article 1. *Nutrition* and *Generation*, one and the same Act of the soul or Formative virtue.

THe *Platonist*, though He holds the Deity, and the world to be coeternal, doth yet allow the World to have been created by God: and to solve the seeming contradiction, saith, that *Priority* was not [κατὰ χρόνον] in respect of *time*, but [κατὰ φύσιν] in respect of *Nature*; as the Sun and light are coævous, though the one be the Cause, the other the Effect. This, certainly, might be more justly said of the *Generative* & *Nutritive* Faculties (if at least, they be not one and the same); by one of which an Animal is *produced*, and by the other *conserved*. For, though the *Formative* Virtue may seem to precede in its operation; yet are the *Stamina*, or rudiments of the Embryo scarce delineated, or adumbrated, when the *Nutritive* begins to augment and perfect them: So as that it may rather be said to go hand in hand with the Plastick's faculty, than to follow after it; and what priority there seems to be in their o-

 perations,

perations is rather in respect of Nature, than of time. To forme, and nourish, are not only acts of one and the same souls but so alike, that it is no easie matter to distinguish betwixt them. For, *Generation* and *Accretion* are not performed without *Nutrition*; nor *Nutrition*, or *Augmentation*, without *Generation*. To nourish, is to substitute such and so much of matter, as was decay'd in the parts, namely flesh, nerves, veins, arteries, *&c.* And what is that in reality, but to generate flesh, nerves, veins, arteries, *&c.*? In like manner, *Accretion* is not effected without Generation; for all natural bodies, upon the accession of new parts are augmented, and those new parts are such of which these bodies were first composed: and this is done, according to all the dimensions; so that, to speak properly, the parts of an Animal are encreased, distinguished, and organized all at once. Farther, this is necessary both in respect of the *Efficient* cause, and of the *Matter*. The *Former*, because *idem esse principium efficiens, nutriens, & conservans in singulis animalibus, necesse est, nisi aliam formam in puero, aliam in adolescente, et in sene aliam constituamus.* The *Latter*, because all Animals (such as are produced *per Epigenesin*, of which is our discourse; not of such Insects, as are produced *per Metamorphosin*) are corporated of one part of the matter prepared by the Formative Spirit, and nourished and augmented by the rest. For, Nature doth nourish and amplify all parts of an Animal with the same matter, or humour

As well in respect of the *Matter*, as of the *Efficient*.

(not

(not with a diverse) out of which she constituted or framed them at the first. Because, whatsoever is superadded to the parts, during their growth, ought to be of the same substance, with what was præexistent, and so must consist *ex congenere materiâ*: their Renovation as well as first Corporation being effected by *Epigenesis*, Aggeneration, or superstruction. So that we may well conclude, that Nutrition is nothing else but *continual Generation*: and as necessary to the Conservation of every individual nature, as Generation it self is to the conservation of the Universe.

2. The necessity of *Nutrition*, two-fold, viz. *Augmentation* & *Conservation*.

To make this Necessity the more evident, we are to consider; (1) That forasmuch as an Animal cannot performe all the functions, of which its nature is capable, whilst it remains in the minute parts, and rude beginnings, in which it is first formed; therefore, there must succeed a Nutrition, that may dilate and amplify those slender *stamina*, by interweaving and assimilating so many other congenerous parts, as serve to advance and augment the Animal to a convenient magnitude: (2) That since the chief principle of life in every Animal, is a certain indigenary Heat (analogous to pure flame, such as the most rectified Spirit of Wine yeelds, upon accension) which by continuall motion and activity agitating the minute and exsoluble particles of the body, doth dissolve, and consume, or disperse them; of necessity, the whole Fabrick would soon be destroy'd, unlesse there were a continuall re-

novation or reparation of those decayes, by a substitution and assimilation of equivalent particles, in the room of those dispersed and absumed. So that, we see, the Necessity of Nutrition is *Two-fold*; one in respect of *Augmentation*, the other in respect of *Conservation*.

As to the continuall *Decay*, or *Depredation* of the substance of our bodies, wherein the latter necessity of Nutrition doth consist; that we may the better understand the manner how it is effected, we are to enquire into the Causes thereof, *viz.* the Agent or Depredator, and the Matter or substance depredated.

3. The Efficient cause of the consumption of the parts, is the *Vital Flame*

The *Agent* or *Efficient* Cause, with all Philosophers, we hold to be the *Naturall Heat*, or *Vital Flame*, at first kindled, by the vegetative soul, or Plastick spirit, in the blood, constantly burning in the Heart, as in its fountain, or primary *Focus*, and thence by diffusion of it selfe through the arteries, warming, cherishing, and enlivening all parts of the body. This *Lar familiaris* is called ἔμφυτον πῦρ, *ingenitus ignis*, by *Hippocrates*; ἡ ἐν τῇ καρδίᾳ τῆς ψυχῆς ἐμπύρωσις, *Accensio animæ in corde*, the Kindling of the soul in the heart, by *Aristotle*; and generally known by the name of *Calidum innatum*, the innate Heat. The principle of life, therefore, being a certain Fire, certain it is that the same cannot subsist or endure one moment of time, unless it be perpetually maintained or fed with some convenient ὑπέκκαυμα, *succendiculum*, or Fewell; which is thereby indefinently consumed: for, all Fire whatever (that Elementary Fire,

Fire, which the *Aristotelians* conceive to be so pure, as to need no *pabulum* or aliment, being a meer Chimera) doth conserve it selfe onely by the destruction of the matter, in which it is generated. So that, indeed, we have one and the same Cause both of our Life, and of our Death; or (to speak more properly) our Life is nothing but a continuall Death, and we live because we dye. For, so long we live, as this Vestall-Fire is kept glowing and shining in the sacrary of our heart: and when the same is put out, either by suffocation, or want of sustenance, life is instantly extinguished. And perhaps, it was to this *Euripides* alluded, when he said; *Quis novit autem, an vivere hoc sit emori:*
An emori, hoc sit quod vocamus vivere?

4. The *Matter* thereby consumed, not the substance of the solid parts, but the *Fluid*, and cheifly the *Blood* and *Spirits*.

The *Matter* or *substance* consumed, we conceive to be the *Fluid* parts of the body, especially the Blood and spirits, which having in them something of the nature of oyle or sulphur, are the principal *succendiculum*, or Fewell of the vital Flame: and not the substance of the *solid* parts, at least not in that large quantity vulgarly supposed. For, experience teacheth, that sundry Animals, as Bears, Dormice, Swallows, &c. do sleep all the winter long, without receiving any supply of aliment: and yet have all their solid parts of their bodies, as large and firme, when they awake again in the spring, as when they first betook themselves to their dens or dormitories; nay, if we may credit Naturall Historians, they grow fat in this time of their long abstinence. Which doubtlesse

lesse is to be ascribed to this, that the flame in their heart, all that time, being but gently moved, and burning quietly, doth consume very little of their spirits and blood. In like manner, we have examples of *Leucophlegmatique* virgins, who upon a decay of Apperite, have endured long abstinence from all sorts of aliment: and yet have not been emaciated in any proportion to their so diuturn fasting. So that it is more than probable, that there is not so rapid and profuse an exhaustion of the substance of the solid parts, by the activity of the vital Heat, as Physicians have vulgarly imagined. In many diseases, we confesse, the habit of the body is much extenuated; but that is only a subsidence or flaccidity of the Musculous flesh, caused by the defect of spirits and blood, by which the same was formerly distended and plumpt up; not by any deperdition of the substance of the solid parts.

5. The *Manner* how they are consumed, is by continual *Dispersion*.

Lastly, as for the *Manner* how the blood and spirits (and, if you please to have it so, also the less fixed and more easily exsoluble particles of the solid parts) are absumed by the vital Heat; it may be familiarly explicated by the example of the oyle consumed by the flame of a Lamp. Flame (as reason defineth it) is a substance luminous and heating, consisting in a perpetuall *Fieri*, *i. e*, an indesinent accension of the particles of its pabulum, or combustible matter, and perishing as fast as it is generated: so that fire is made fire, and again ceaseth to be fire, in every, the shortest moment of time; and

and when there remain no more particles in the combustible matter, wherein it may generate it selfe anew, it instantly perisheth. Continuall *Dispersion*, therefore, being the proper effect of Fire; the matter or fewell, whereon it subsisteth, cannot but be in perpetuall flux or decay. In like manner (that we may accommodate this to our present purpose) the *Lamp of life* consisting in a continuall accension of vital spirits in the blood, as that passeth through the heart; those vital spirits, transmitted by the arteries to the habit of the body, no sooner arrive there, but as they warme and vivifie the parts, so do they immediatly fly away, and are dispersed into the air, carrying with them many aqueous parts, and (perhaps) some sulphureous exhalations. Moreover, there being in all parts of the body certain sweet and balsamicall, or conserving spirits, as it were affixed unto and concorporated with them; the vital spirits meeting with and acting upon them, do by little and little render them volatile, and at length wholly disperse them: whereupon the minute particles, in which they did reside, become mortified, &, as excrements of the body, are ejected together with the exhalations of the blood. And this is (as we conceive) the reason and manner of the depredation made upon the parts, by the vital heat.

If your Curiosity extend yet further, and you would enquire into the *Quantity* of Aliment daily devoured by this *Biolychnium*, or Lamp of life; the acute *Sanctorius* will tell you, that, 6. And in what *Quality*.

that, according to his statique observations, men commonly avoid as much by insensible perspiration, in one day, as by stool, in fifteen. But so great is the variety among men, in respect of temperament, diet, age, exercise, the season of the year, and other circumstances; as that no definite compute can be made of this dispence. And yet we may be certain, that the proportion of blood and spirits daily exhausted by the flame burning within us, is very great: and that the most part of the matter of occult transspirations, is the vital spirits, which are continually generated, and continually dispersed.

From the consideration of the Causes and Reason of the Deperdition of substance in Animals, we may opportunely progresse to an enquiry into the Causes and Manner of the *Renovation*, or Restauration of it, by Nutrition.

7. The Efficient *Principle* of the *Renovation* of the parts, what.

The *Efficient* principle (or ἀρχὴ κινητικὴ ἢ ἀναστατικὴ, as *Aristotle* calls it) certainly, is the very same with the Generant, or Formative; because, as we said afore, Generation cannot be without Augmentation, and Augmentation is Nutrition. Not that we are of their judgment, who hold that Life and Nutrition are different, not *in re*, but onely *in ratione*; for, the Embryo is nourished, before the *Empsychosis*: but that we conceive, that Life doth consist in a continuall accension of vital spirits out of the blood, which is the pabulum of the Lamp of life; and that Nutrition doth consist in the restauration of what is consumed, by an Apposition

ſition and Aſſimilation of conſimilar or congenerous matter.

The *Material*, or Conſtitutive principle, we take to be a certain ſweet, mild and balſamical Liquor, analogous to the white of an egge, out of which the chicken is formed. For ſince all Animals are nouriſhed with the ſame, out of which they were at firſt fabricated, according to that common Axiom, *iiſdem nutrimur, ex quibus conſtamus*; and that of *Ariſtotle*, *eadem materia eſt, ex qua augetur animal, & ex qua conſtituitur primùm*; and ſince they have their origine *ex Colliquamento*: we may well conclude, that the *Succus Nutritius* is in all qualities reſpondent to the Colliquamentum of the white of an Egge. Nor are they in the right, who thinke, that the parts of the body being diverſe, thoſe of the Aliment ought alſo to be equally diverſe. As if Nutrition were nothing elſe but a ſelection and attraction of fit aliment; and that there were not required in every part a concoction, aſſimilation, appoſition, and tranſmutation. For, the Aliment of all parts is common, and ſimilary, ſuch as the white of an egge; not heterogeneous and compoſed of diverſe parts: and it is the work of the Vegetative ſoul, as to forme all parts out of one and the ſame homogeneous matter at firſt, ſo afterward to augment and repair them out of the like, by transforming that into the ſubſtance of each part, which is potentially all parts, and actually none. As from the ſame rain all ſorts of plants receive

8. And what the *Material.*

 their

their increment; because the water, which was potentially life to them all, is now made actually life to each, being transmuted into the substance of each. Whereunto the *Philosopher* had respect, when, opposing the opinion of *Anaxagoras*,

Principium rerum qui dixit Homœomesiam,

De gen. Animal. l. 2. c. 4.

He saith; *Distinctio partium non, ut quidam opinantur, propterea fit, quia simile suapte natura ad simile fertur: nam præter alias multas, quas ratio ista habet difficultates, accidet, ut quævis pars similaris seorsim creetur Verbi gratia, ossa per se, & nervi, & carnes; si quis eam causam approbet, &c.*

9. And the *Manner* how they are renovated.

Lastly, as to the *Manner* how the parts are refected, or instaurated; it is most probable the same is effected by *apposition*, *agglutination*, and *assimilation* or *transmutation*: all which must in order succeed each other, before the act of Nutrition can be compleat. For, the *succus nutritius*, being first prepared in the stomach and other organs thereunto inservient, must be brought and apposed to all the parts, that are to be nourished; then from contiguity by apposition it must be advanced to continuity, by agglutination; and lastly made of the same substance with them, by assimilation or transmutation, which is the perfection or ultimate term of Nutrition.

10. *Consectary*, of the *twofold* Expence of the *Chyle*.

From what hath been said, it easily appears, that the expence of the Aliment (at least of the Chyle extracted from it) is *twofold*; one part thereof, being converted into the *succus nutritius*,

nutritius, for the instauration of parts: the other being converted into *Blood*, both for the fewel of the vitall flame, and for the confection of Spirits. That we may, therefore, the better understand the processe of Nature in both these Operations; it is fit, we enquire into the method of *Chylification* first, and afterward into that of *Sanguification*: that we may comprehend the whole history of Nutrition from the beginning to the end.

OF CHYLIFICATION.

Exercitation the Second.

Of Chylification.

Article 1. The *Order* of the Meat in the stomach.

WHen we eat, whatsoever of solid Aliment is detruded into the Ventricle or stomach (for Deglutition is by way of detrusion) doth for a while observe the same order, in which it was swallovved dovvn; vvhat vvas first taken, lying undermost, and vvhat last, uppermost: unlesse it chance, through intemperance, that an excessive quantity of drink so distend the stomach, as that the meat be set afloat; and then that order is changed into confusion.

2. The *Posture* of the stomach, in Concoction.

When our hunger is satisfied, and repast finished, the stomach doth dilate it self more or less, according to the proportion of meat and drink received, so as to imbrace the same

closely and strictly on all sides; and then shut both its upper and lovver orifice; the upper, that vapours may not ascend to the brain, and that the concoction may be the more perfect; the lovver, left any of the meat should descend into the guts, before it be converted into perfect chyle. Yet the lovver seems not so strongly contracted, as the upper; because it hath been observed, that upon even a gentle compression of the body of the stomach, it easily yeelds to the pressure of the yet half-concocted meat, and permits it to pass into the guts. And sometimes the stomach is so vveakned, by surfeits and frequent distension, as that neither of its orifices is dravvn together so closely, as it ought to be; and in such case the Concoction is alvvayes imperfect.

3. The Dissolution of the Meat, by an *Acid* humor found in the stomack.

The meat thus received into, and embraced by the stomach, is by and by moystned and diluted, partly by the drink, partly by a certain *Acid* humor contained in the stomach. Which being endovved vvith an incisive, penetrating, and dissolving faculty, doth as it vvere cut, and dissolve the solid meat into very small pieces, and (like an excellent menstruum) extract all the laudable and alimentary parts of it, *ad modum Tincturæ*. But vvhether this Acid juice be ingenite in the stomach it selfe, or sent thither either from the Spleen (as hath been vulgarly believed) or from the cæliacal arteries (as is most probable) vve shall hereafter professedly enquire. In the mean vvhile, certain it is, that this Acid liquor (or spirit, as some

some have named it) is so necessary to the stomach, as that it cannot happily performe its Office of Chylification vvithout it. For (to omit hovv much the same conduceth to excitement of Appetite) vvhen it is vvanting, the concoction is rendred so imperfect, as that the meat is avoided vvhole, as it vvas svvallovved dovvn; vvhich *Hippocrates* seems to intimate, in the 1 *Aphor.* 3. *sect.* vvhere he saith, *In longis intestinorum lævitatibus, si tactus acidus fiat, qui prius non erat, signum bonum est.* Certain it is also, that this Acidity, as it is not excited but by a moderate heat, so it is discussed and destroyed by an excessive. Which is the reason, vvhy the appetite is vveak and languid in phlegmatique constitutions, and cold distempers of the stomach; and in Fevers, and hot distempers, vvholly taken avvay. Like as bread is very hardly leavened, in a cold place, and in an Oven not at all. But, we return from our digression.

4. Which causeth a certain *Fermentation* of the Chyle therein.

The mixture of the solid and liquid parts of the aliment, being by this time advanced *usque ad minima*, so as the vvhole appears to be, one and the same fluid substance; in the next place succeeds a *Fermentation*, not unlike the motion arising in vvine, vvhile it defæcates it self. Which *Fermentation* vve understand to be a certain Heat and agitation of all parts of the liquor, arising from a contest or strife betvvixt the Spirits and crasser parts, vvhile the Spirits endeavour to expand themselves, and flye avvay, and the gross parts oppose

pose and hinder that their endeavour. Now this is that motion, which being equivalent to long Elixation, doth so fully impraegnate the potulent part of the Aliment, with the spirits and virtues of the solid, as that it puts on the form of a whitish juice, in colour and consistence not much unlike the Cream of barly, generally called the *Chyle*, as the function or action of the stomack, by which it is so confected, is called *Chylification*.

5. All parts of the Aliment, not Chilified at once, but successively; and the first Chylified, first discharged into the Guts.

But, here we are to advertise, that all the meat doth not receive this commutation equally soon; it having been observed in dissections, that some parts have been perfectly converted into chyle, and that chyle detruded into the intestines and milky-veins; while the rest have remained wholly crude. Nor is it reasonable, that the whole mass of Chyle should be detained in the stomack; or that what is already concocted, should there stay and expect the perfection of what is not concocted: but that as fast as the chyle is made, so fast should it be discharged out of the stomack.

6. The *Time* required to perfect Chylification, various, according to divers respects.

We are to advertise also, that as to the *Time* wherein the work of Chylification is wholly consummated, there is no small variety; as well in respect of mens individuall temperaments, as of quantity and quality of meats they eat, and also of the time of their meals, with other circumstances. For, in some men the digestion is compleated in 3, 4. or 5. hours space; while in others it extends to 8. 10. nay

13. which certainly is to be ascribed chiefly to the abundance of heat and Acidity in the stomacks of Those, and to the decay of them in These. Again, by how much the greater *quantity* of meat is devoured, by so much the slower is it digested. The same likewise may be said of the *quality* thereof; because the grosser, tougher and harder the aliment is, by so much the more difficulty is it comminished, cutt, dissolved, and fermented; and consequently the longer before it be concocted. Moreover, concoction is performed in the *day* much sooner, than in the night; notwithstanding the vulgar opinion, of the recession of the naturall heat towards the stomack, in sleep, for the promotion of Chylification: because in the day, by reason of motion and exercise, the Circulation is more free and swift, and so the distribution of the Chyle more expedite. Lastly, *Mastication* of the meat in the mouth is so necessarily præcedaneous to concoction; as that by how much the smaller the morsels are, and the better chewed, by so much the sooner are they digested. Nay; among the parts of the same meat, there is no lesse variety; so that some parts of bread and flesh commonly remain unaltered, a good while after others more tender and exsoluble are transformed into perfect chyle, and protruded into the guts. So that no certain time can be assigned to Concoction in all men. But Nature it self hath given us a signe, by which every single person may know, when this chylification is finished in his stomack;

mack; and that is a sense of emptinesse, and appetite to a supply or recruit of Aliment.

THE JOURNEY OF THE CHYLE

Exercitation the Third.

Article 1. The traduction of the Chyle, from the stomack and intestines, into the common *Receptacle*, through the *venæ Lacteæ*.

THe Chyle, being, according to the manner declared, perfectly concocted, is by degrees (the stomack gently and gradually contracting it self) expressed or detruded into the Guts; and not attracted by them, as hath been commonly taught. The Guts being filled with this liquor, and by a certain peristaltique motion, or undulation, like that of worms creeping, contracting themselves successively from the first to the last; transmit the same downward. And as it passeth through them, there is a separation made of the profitable or alimentary part, from the unprofitable or excrementitious: the latter to be excluded by stool; the former to be protruded into the *Venæ Lacteæ*, or milky veins. Which opening themselves by small orifices or inletts, in infinite number, into the coats of the intestines; and running in continued channells from thence into the Mesentery: carry the Chyle into a certain common Receptacle or Gulph (called *Receptaculum Pecqueti*, from the inventor) consisting of a membranous substance, situate at the root of the mesentery, upon the *vertebræ lumborum*,

lumborum, and filling the space betwixt the Muscles *Psoæ*. From this common Receptacle there are derived other *ductus chyliferi*, which running upwards, neer the spine of the back, through the Thorax, and propagated quite home to the subclavian branches of the *vena Cava*, neer the external jugular veins, exonerate themselves into them; so as the Chyle being there commixed with the blood, is by the ascendent trunk of the *vena Cava*, soon imported, together with its new associate, the blood, into the right ventricle of the heart. And this, according to the late invention of *Perquet*, and anatomical experiments of the most accurate Dissectors since, is the true Traduction of the Chyle from the ventricle to the heart: at least of so much of it, as is to be converted into blood, for the fewell of the vital Flame, and confection of vital spirits.

2. Of which there are two kinds, *one* arising from the Intestines; the *other* from the Glandules, in the *Abdomen*, into which the former sort exonerate themselves.

That we may, with the more exactness and certainty, trace the footsteps of the Chyle in all its progress through these various and obscure Meanders; we are to observe, from Anatomicall Demonstrations, two things concerning the Chyliferous Conduits. *First*, that there are (besides the Common Receptacle, and channells from thence ascending to the chest and subclavian veins) two kinds or sorts of the venæ Lacteæ; one arising in slender capillary roots from the Intestines themselves, and thence delated through the Mesentery to some glandule or other, situate either in the Mesentery it self, or not far from it in some o-

ther part of the Abdomen, and there disseminated into capillary surcles: the other taking its origine out of that very Glandule, into which the former sort exonerate themselves. *Secondly*, that the Glandules in the Abdomen are not seated in the same places in all men; but are variously posited, here in some there in others, according as Nature (sometimes affecting variety in the same species, where conveniency admits thereof) pleaseth to fix them; and this without incommodity to the body: and that from the incertainty of the position of these Glandules, the Distribution of the venæ Lacteæ comes to be also various and incertain. For, Anatomy sensibly attesteth, that all the small surcles of the *venæ Lacteæ* of the former sort (arising from the intestines) do constantly tend to some one Glandule in the lower belly; and are distributed into the same, before they arrive at the Common Receptacle, or disembogue themselves into any vein; yea (as was newly said) that they produce another race of Capillary branches in the Glandules, in which themselves were terminated; and that many of those small rivulets concurring and uniting, make one greater channell, before they lose themselves either in the Common ocean, or any branch of the *vena Cava*. Now, from the foresaid various position of the Glandules, it comes to pass, that the Distribution of the venæ Lacteæ into their substance, and their new propagation out of them again, are so uncertain, as that it hath given occasion to some

Anatomist

Anatomists to suspect, that the *venæ Lacteæ* are disseminated into very many parts of the body; when, indeed, they only come neer those parts, and then passe by them, without effusing any part of the Chyle into them.

Now, from these observations, it is very probable, that all the *venæ Lacteæ* (before the Chyle loseth its milky colour) do exonerate themselves either into the vena Cava, or some branches of it. And as for the *Lacteæ Thoracicæ*, our sense demonstrates, that they empty themselves into the subclavian or Axillary veins (branches of the *Vena Cava*); so that none disgorgeing their fraught or chyle into any branch of the *vena Portæ*; it is most manifest, that no part of the Chyle is imported into the Liver (as was long believed and taught), there to be converted into blood; and consequently that the office of the Liver is not Sanguification.

3. But none of either kind tend to the Liver.

Whether any of the *venæ Lacteæ* are distributed into the *Paps*, and *womb*; in women; though highly probable, is yet in dispute: no Anatomist having hitherto been so happy in his searches, as to discover by what secret wayes or passages they tend to either. We say, highly probable; for, according to that judicious saying of *Hippocrates*, *Licet visum oculorum effugiant, ea tamen mentis acie comprehendantur*; though they have thus long concealed themselves from the eye of the body, yet are they obvious to the eye of the Mind: and the acuteness of our Reason may herein supply the dullness of our sense. Now, to evince the probability

4. That the Milk in the Papps is not made of Blood, but of meer Chyle brought thither by some peculiar vessels: because

bility of this Opinion, let us consider the sundry and weighty Arguments, that seem to assure, that *the Milk in the paps is not made of blood; but mere Chyle brought into them by some peculiar vessels.* Which though a seeming Parergy, is yet fully pertinent in this place.

5. There are no convenient conduits, by which Blood can be brought into the paps, in sufficient quantity.

First, there are *no convenient ways or conduits*, by which Blood may be, in a due quantity, imported into the Paps, there to be whitened into Milk. For (1) the *Arteriæ Thoracicæ* can adferre but a small tribute of blood into the treasury of the Paps; and what they bring in, is soon exhausted and carried off again by the veins; according to the apodictical doctrine of the Circulation of the blood. But, did the blood remain in them; yet would it hold no reasonable proportion to the large quantity of milk usually effused in a day (which in healthy Nurses commonly amounts to two pints). Because the Arteries disseminated into the Paps, are exceeding small, as our eyes witness, and *Vesalius*, long since well observed, where He saith, *Exiguæ aut ferè nullæ arteriæ adeunt mammas, quod in mammarum cancro affectarum ablatione constat, ubi paucæ aut ferè nullæ arteriæ sanguinem fundunt, cùm tamen venarum magna copia sit.* (2) The Arteriæ Hypogastricæ cannot be thought to convey blood into the Paps; because they are terminated in a part far distant from their confines, and empty themselves where their streams are soon swallowed up and returned into the vena Cava by the Hypogastrick veins. (3) The same may be said of

Examin. observat. Fallop. pag. 89.

of the Epigastrick arteries and veins. So that in respect of wayes importing blood into the Paps, it appears altogether unlikely, that that should be the matter of Milk.

Secondly, *Blood is not a fit, nay not a possible matter for the generation of Milk.* For (1) if blood should be imported into the paps, in sufficient quantity, and there extravasated; certainly it would be converted rather into *pus*, than into milk, as is frequently observed in Inflammations and Apostems of the Paps. (2) To what end should nature convert blood into milk, when that milk is to be soon converted again into blood, in the infant sucking it? (3) How is it possible, that the Chyle, which loseth its whiteness and other qualities, when it is transformed into blood; should resume them again, as soon as it becomes milk; *a privatione ad habitum*, is repugnant to Nature? (4) Meat and drink cannot be suddainly changed into blood, and that blood changed into milk; but experience teacheth, that the paps of nurses are filled soon after their repasts, and many women feel their milk flow swiftly into their breasts, almost as soon as they have drunk. (5) Women that are somewhat fat, have greater plenty of milk, than such as are lean: but, if blood were the matter of milk, the lean would afford more milk, than the fat; because the lean have larger arteries and veins, and so more store of blood. (6) If blood were the matter of milk, then would the bodies of Nurses fall into dangerous sicknesses, from excess

6. Blood is nor a fit, nor possible *Matter*, for the generation of Milk.

of

of blood, soon after they cease to give suck; because being long accustomed to the generation of so profuse a quantity of blood, for the supply of their milk; and that daily evacuation thereof ceasing, the whole body must needs be oppressed with that redundancy: but, they seldome complain of any *Plethora*; therefore &c. (7) If blood, not chyle, were the matter of milk, then were it impossible the milk should retain the odour and qualities of the meats eaten; since no manifest quality of the meat can be deprehended in the blood; much less in what is generated of blood, as being one remove further from it: but the Milk doth frequently retain the odour and other qualities of the meat and drink; Ergo. This is attested by the experience of Physicians, who give purging medicaments to Nurses, when there is cause to purge their children. *Prosper Martianus*, the best Commentator upon *Hippocrates*, hath an observation of a woman, who having taken a purge, soon after gave her child suck, and thereby endangered the childs life, a superpurgation ensuing in the child, while herselfe felt no effect of the medicament at all. No obscure argument, that the Milk deriveth its purgative faculty from the Chyle, not from the blood; for if it were to be carried so long a journey, as through the heart and arteries, and therein undergoe so many and great changes: doubtless the virtue of the medicine would be much weakned and dulled; nor could it be derived into the paps, so soon after it was first received

Comment in lib. Hippocr. de nat. pueri.

received into the stomack. Here may we seasonably recite that saying of *Aristotle*, *Si lactans pilum cum cibo aut potu angerat, ad mammas pervenit, & in earum papillis consistens, morbum inducit, qui τριχίασις nominatur*: and that rare observation also cited by *Martianus*, of a piece of a root of Cichory eaten in sallade by a nurse at night, and taken out at one of her nipples the next morning. But, above all, this Experiment is most convincing. Let a nurse drink a good draught of milk tincted with Saffron; and within an hour or two after express the milk out of either of her paps, into a glasse or other small vessell: and that milk shall have the odour, sapour, yea and the very colour also of Saffron. (8) Nor is the Milk made of the Menstruous blood, as some Philosophers have dream't; because many bruit Animals have milk, that never suffer the monthly flux; because most new-born infants have some milk in their paps, as *Dr. Harvey* hath well remarked; and because even Men themselves have been found with good plenty of milk in theirs also. *Schenchius* affirms, that he knew one *Laurentius Wolfius*, who from his youth to the 50 year of his age, had aboundance of milk flowing out of his duggs every day. The like is asserted of a certain Flemming, by *Wallæus*; and of divers others by *Cardan*, by *Benedictus*, by *Aquapendens* and other credible Authors. Nay, Historians report, that in *America* there are whole nations, among whom the men generally abound with milk, and suckle their children.

7. *De hist. Animal. cap.* 11.

Loco citat.

De gen. anim. exercit. 55.

dren. To which we may adde, that many nurses have their Termes, while they give suck, and yet find no diminution of their milk, at those times, more than at others. So that we see, how unreasonable it is to conceive, that bloud is the matter of Milk.

7. *Milk* and *Chyle* agree in all their manifest *Qualities*, and are reciprocally convertible.

Thirdly, Milk and Chyle seem to be one and the same thing; as may appear both by their mutuall agreement in all their qualities, and by their easie reciprocall convertibility. As for their *resemblance in manifest qualities*; (1) They both have a fatty substance: otherwise neither could be fit either to sustain the Lamp of life, or to instaurate the parts; nor can the bloud contain any such fatty substance in it, but what is derived from the Chyle. (2) As Milk doth consist of two parts, the *serum* and *crassamentum*; so likewise doth Chyle, whose *serum* is dreyned away by the kidneys, and *crassament* by the guts. (3) As Milk, if kept over-long, especially in a warm place, or corrupted by any Acid juice, doth turn sowr; so also doth the Chyle, and in the stomach of Calves is found a certain sowr serum, which housewives use for the coagulation of their Milk; in like manner the same is frequently generated in the stomachs of men, which being ejected by vomitting, sets the teeth on edge; having acquired that sowrnesse either by corruption from excessive heat, or by the admistion of a melancholy juyce. (4) They are equally sweet in tast; which is the reason, why many brute Animals lick up the

the milky liquor flowing from the ſecundines, when they bring forth their young, which is indeed the nutriment of their young, while remaining in the womb. (5) They reſemble each other in colour, being both white; as the ſenſe teſtifieth. (6) They both contain certain ſmall Fibers, that ſeem to be educed from the more viſcous and glutinous parts of the aliment. And theſe, doubtleſs, are thoſe Fibers, which ſenſibly uniting themſelves in the ſuperfice of bloud let forth into a cold veſſel, appear in form of a whitiſh film, or thin skin; long miſtaken by Phyſitians for cold, viſcid and phlegmatique matter commixt with the bloud: and if the red parts of the bloud be gently waſhed away from them, they become diſtinctly viſible. And as for their *reciprocal Convertibility*; that is clearly proved by this, that Chyle is eaſily converted into milke, in the Nurſe; and that milk again converted into Chyle in the ſtomach of the Infant that ſucks it. Now theſe many reſemblances conſidered, we may ſafely conclude, that they have much more of reaſon on their ſide, who conceive Milke to be nothing but meer Chyle brought from the ſtomach to the Paps, by peculiar paſſages; and therein promoted to ſomewhat more of perfection: than they, who think it to be made of bloud whitened in the glandules of the paps.

8. That Chyle is imported alſo into the *womb*, in pregnant women.

Having, with ſo great veriſimilitude, brought Chyle from the ſtomach to the Paps, for the ſuſtenance of the infant, after he is born;

it remains now that we see, whether any portion thereof be deduced also to the *womb*, for his nourishment before he is born. First, therefore, let us seriously consider, what light hath been anciently given to this obscure disquisition, by that Genius of Nature, *Hippocrates*; who hath sundry pregnant Texts to this purpose.

9. From the Authority of *Hippocrates*, &

lib. de Natur. pueri.

Uterum fœtu grandiorem (saith He) *comprimere mulieris ventrem, & quod in cibo potuque est pinguissimum & candidum, magisque uteri calore dulcoratum, in mammas tendere, & in uteros quoque exiguam portionem per easdem venas deferri.* In which words the reverend Author toucheth upon two things very considerable and pertinent. (1) That the fat, white, and sweet Chyle is carried up to the paps, by *compression of the Venæ Lacteæ*, and *the common Receptacle* of the Chyle; the swoln womb being incumbent upon them, and pressing the Chyle upwards. For, that Compression cannot be understood of the veines and arteries in the lower belly, as if they were thereby urged to disgorge their bloud into the paps, for the generation of milk; because, a compression of those veins and arteries, that are neer the *Vertebræ Lumborum*, would necessarily hinder the course and recourse of the bloud, requisite to the work supposed. But, as *Perquet* will have the weight of the Liver, moved up and down in respiration, to conduce to the compression of the stomach, *venæ lacteæ*, and receptacle, from the upper part of the abdomen: So will *Hippocrates*

pocrates have it, that, from the lower part, the compression of the womans belly by the greatnesse and weight of the child, doth cause the Chyle to alter its course (his words, in another place, being, *convertitur ad mammas, quod est dulcissimum ex humido*) and flow upward to the paps. Thus the Scythians, as *Herodotus* reports, had a trick to blow up the wombs of their Mares, by certain sufflatoria ossea, like pipes, to the end that their bellies being compressed by the swelling of their wombs, the greater abundance of Chyle might be protruded into their udders, and so their milke encreased. (2) Since by reason of the same Compression, the passage of the Milk, by vessels tending from the paps to the womb, is not so open and free, as while the burthen of the womb was lesse; thence it comes, that so small a quantity of the Chyle is imported into the womb, as will not suffice to the nourishment of the *Fœtus*. Much Chyle, therefore, flowing to the paps from the *Venæ Lacteæ*, and the Common Receptacle; and some milk also reflowing from the womb to them, by reason of this Compression mentioned; it is no wonder, if the paps at that time swel above measure;

lib. de Mulier.

A second memorable place of *Hippocrates*, to this purpose, is that; *Ad mammas enim & uterum ejusmodi venulæ, & consimiles, feruntur. Cumque ad uterum perveneri, lactis formam habet, eoque exiguo puer fruitur: mammæ verò, ubi lac exceperint, attolluntur & implentur.*

libr. citat.

A third, to the same effect, is this; *Fœtus quod in sanguine dulcissimum est, ad se trahit, simulque aliquantulâ lactis portione fruitur.* Where He hinteth the true cause, why it is unwholesome and dangerous for Infants to suck women with child, *viz.* because the best of the milk is attracted by the Fœtus, in the womb, and the worst is carried to the paps. Which He more expressly declares in these words, *Dum mammæ exsuguntur, venæ quæ ad eas tendunt ampliores redduntur, & ampliores effectæ quod pingue est è ventre attrahunt, & in mammas transmittunt*: giving the reason, why the fat and richer parts of the milk do not ascend to the paps, till after the birth of the child, who by frequent sucking doth dilate and amplifie the vessels (formerly too small) through which the milk is to pass from the womb to the paps, and so make them more capable of the thicker liquor; and hence, doubtlesse is it, that the milk in womens breasts is alwaies much thinner and wheyish, while they are with child, than after their delivery.

10. Of Dr. Harvey.

From *Hippocrates* the First, let us go to *Hippocrates* the Second, the immortal *Dr. Harvey*; who, by frequent dissections of prægnant and suckling Animals, discovered that there is Chyle or milk imported into the womb. For, describing the *Cotyledones* or *Acetabula* of the womb, He saith; *Cavitates istæ spongiæ majoris loculamenta magnitudine non excedunt; inque singulas earum, totidem vasorum umbilicalium ramuli tenuissimi profundè penetrant: quippe in iisdem*

Exercit. de Uteri membranis & humoribus.

dem alimentum fœtui reconditur; non quidem sanguineum, sed mucosum, ovique albumen crassius planè referens. Unde etiam manifestum est, bisulcorum Animalium fœtus (ut & alios omnes) sanguine materno non ali. And, in the subsequent paragraph, He adds, *coarctatis hisce acetabulis, non sanguis, sed albugineus liquor emanat; eodemque expresso, illa statim contracta, albidiora, & flaccida conspiciuntur; ac demum mammarum papillas, aut verrucas pensiles majores referunt*: And a little after, *Opinor, carunculas omnes (uberum modo) non sanguinem, sed succum albumini similem concoquere, eundemque fœtui subministrare.* Again, in another place, tracing the way of this milky juice more accurately, He saith; *ab utero per cotyledones pertingit ad carunculas placentæ; quas quidem si digitis compresseris, ex earum una aliqua (tanquam ex papilla) succi istius alibilis facilè cochlearis mensura emulgetur: idque nullo apparente sanguine, quem attractu etiam valido, numquam elicueris; quinetiam caruncula sic emulcta atque inanita, compressæ spongiæ instar contrahitur & flaccescit; plurimisque foraminibus pertusa cernitur. Adeò ut omnibus indiciis pateat, carunculas istas esse ubera uterina, sive albuminis nutritii conceptacula.* And a little after, He expressly affirms, *succum illum in Gravidis ante partum, in acetabulis conservari; post partum verò, ad mammas deferri.* Than which nothing can be more plain, more positive.

II. And from the *sympathy* betwixt the womb and the paps.

To the Authorities of these great men, let us adde the consideration of that great *Sympathy* or consent betwixt the womb and paps, so

so frequently observed in women. Which Consent cannot be caused by nerves, nor by veins, nor by arteries, nor by similitude of substance, nor by contiguity of situation; and therefore most probably, by mediation of these presupposed Chyliferous vessels tending from the paps to the womb. (1) Not by *Nerves*; because the paps derive their nerves from the fourth intercostall pair, or the fifth pair of the thorax: and the womb is supplied with sense from the nerves of the *os sacrum*, and also from the sixth conjugation of the brain. (2) Not by *veins or arteries*; because they are, both, destitute of sense, as *Galen* himself affirms. (3) Not by *Similitude of substance*; because the paps consist mostly of Glandules, and the body of the womb is membranous. (4) Not by *Contiguous situation*; because the paps and womb are far distant each from the other. It being, therefore, most certain, that all sympathy betwixt parts of the body, doth arise either *ex Vasorum Communione*, or *ex operis societate*, or both; and that betwixt the paps and womb there is no communion of vessels, unlesse it be of some chyliferous vessels derived from those to this; and that there is a society of office betwixt the paps and womb, both containing the Aliment of the child: it is highly consentaneous to truth that there are such vessels (though yet undiscovered) by which the Chyle is carried from the paps to the womb, while the infant remains therein, and back again from the womb to the paps, after he is born. This being granted, we

may

may cleerly understand the wayes and manner of the ascent of the milk from the womb to the paps; and the reflux of it from the paps to the womb, so frequently mentioned by *Hippocrates*. We may understand also, how the good or evill affections of the womb are communicated to the paps; and how it comes, that a Cancer cured in the paps, doth revive and grow again in the womb, and *vice versâ*. And thus may we understand those Aphorisms of *Hippocrates*; *Si gravidæ mammæ graciles fiunt, repente illa abortit; si gravidæ lac multum è mammis effluit, fœtum imbecillum significat; si solidæ mammæ, fœtum saniorem*. In respect of these vessels, are we moreover to interpret that Rectitude of consent betwixt the papps and womb, intimated in that Aphor. *Gravida gemellos gerens, si dextera mamma fiat gracilis, marem; si verò sinistra fœminam abortit: fœtus enim mares in dextris, fœminæ in sinistris magis.*

To conclude this Disquisition, therefore, since it is manifest that there are some such Chyliferous vessels, or *ductus*, by which the paps and womb have a reciprocall commerce; it is not improbable, they are derived from the extremities of the Chyliferous veins of the thorax, where those enter into the subclavian veins, or the branches of the *vena cava*; being disseminated on each side one, to each pap; whereunto so soon as they have insinuated themselves, and dispersed several small surcles, to lead a long the chyle to the nipples, they may be conceived to emit others branches

12. A conjectural description of the *Chyliferous vessels* tendin from the paps, to the womb.

ches downward along the abdomen, that insert themselves into the womb, on each side one; and perchance some one also into the bladder, it having been observed, that Chyle hath been avoided by urine. But, what need we thus anticipate, by conjecture, when we dayly expect the discovery of the wayes through which they passe, by Anatomists, who now a dayes exercise themselves in strict enquiry after them?

OF SANGUIFICATION.

Exercitation the Fourth.

Of Sanguification.

Article 1. The most part of the Chyle is converted into blood.

FRom the smaller and lesse conspicuous Rivulets of the Chyle, we now come to survey the grand and plainly visible Current thereof; which being imported (as we formerly declared) into the subclavian veins, from them into the *vena cava*, and thence immediately disembogued into the right ventricle of the heart, is therein converted into a liquor of a different colour and nature, *viz.* Bloud, for the fewell of the vital Lamp, and the continual refection of spirits vital. And here we are (for method's sake) in order to consider (1) The *Mutation* which the Chyle ariving at the heart, doth therein suffer, or the Action its

self,

ſelf, called Sanguification; (2) *The Agent*, or principal Efficient of that Mutation; (3) The *Manner* how it is effected; (4) The *Uſes* of the Bloud, after it is made; (5) The *Motion* of the ſame, in order to thoſe uſes.

Concerning the *FIRST*, viz. *the Action of Sanguification*; we advertiſe, that it is not an Organical action, or ſuch as depends upon the peculiar conſtitution, or fabrique of any Organical part of the body; but meerly a *Similary* one. For, ſince the bloud, when made, is a ſimilar body; and the Chyle of which it is made, is likewiſe a ſimilar body; and that the Chyle doth not become bloud, by ſeparation of any one or more parts of it, from any other (as the Urine and Bile are made) but only by a kind of Exaltation of its nature, or an advance of thoſe Natural ſpirits it containeth, into vital or more ſublimed and active ones, while the vital ſpirits, præexiſtent in the Ventricles of the heart, do enkindle the ſame heat, and cauſe the ſame diffuſive or expanſive motion in the Natural, which themſelves have formerly acquired: we ſay, conſidering theſe things, it is manifeſt, that the work is done by *ſimple Aſſimilation*; and conſequently that Sanguification is an Action *ſimilar*, not Organical, as hath been long erroneouſly affirmed.

2. Not by an Organicall, but a *Similary* Action.

Concerning the SECOND, *viz.* the *Efficient*, let us firſt examine what that cannot be; and ſo we ſhall the more eaſily and certainly find what it muſt be. The prime Agent, or Author

of the work of Sanguification, is not either the *Liver*, as *Galen* and his Sectators conceived and taught; or the *veins*, as some Anatomists have dreamed; or the substance of the *Heart*, as *Aristotle* and his Disciples have asserted; or any other organ of the body.

3. Whose Primary Efficient, is not the *Liver*;

To be more particular; we affirm, the *Liver* not to be the Agent in the work of Sanguification; and that for sundry reasons. (1) No part of the Chyle is brought to the Liver, by any one or more of the Venæ Lactæ: they in the lower belly generally exonerating themselves into the Common Receptacle; and those in the Thorax being terminated in the subclavian veins: and therefore it is impossible the Liver should transforme chyle into blood, when no chyle can arrive thereat. (2) There is blood to be seen in an Embryo, before even the very rudiments of the Liver are delineated; and what hath beeing before, cannot be the effect of what hath no beeing till afterward. That the blood hath priority of existence, is manifest from the observations of *Dr. Harvey*, who expresly affirms, *Sanguinem dari, antequam quicquam corporis reliqui existat; esseque eum, præ cœteris omnibus fœtus paribus, primogenitum; & ab ipso, tum materiam, ex qua corporatur foetus, tum nutrimentum, quo augetur, procedere; esse denique (si modo ulla fuerit) primam particulam genitalem.* (3) After the Chick is perfectly formed in the egg, and hath its veins and arteries replenished with blood; yet doth the Liver still remain pale and whitish,

de gen. Animal. exercit. 18.

not

not without ſome ſmall tincture of yellow, which obſervation doth of it ſelf alone demonſtratively depoſe the Liver from the office of Sanguification, and conferre that dignity upon ſome other Agent. For, how can the Liver, ſuppoſing the Chyle were brought to it, give a deep redneſs thereunto, while it ſelf yet continueth white? Can any thing give that to another, which it ſelf hath not? This alſo is certified by the experience of *Dr. Harvey*, who thereupon firmly concludes; *jecur & calorem, & colorem ſuum à ſanguine mutuatur; non autem ſanguis à jecore.* From hence it may be obſerved, that the native colour of the Liver is not red, but pale, with a faint mixture of yellow; and that, what redneſs it doth afterward acquire, is communicated to it from the blood continually percolated through the parenchyma of it. Both which may more plainly appear by this, that in a Chick not yet excluded from the ſhell, that yellow paleneſs of the Liver is viſible, even the very laſt day of the Hens incubation; though at that time the ſame begins to incline toward ſome degree of redneſs, which is more and more augmented every day after the chick is hatched. Again, if you fill a bladder with warm water, and through a ſlender pipe inject the ſame, by the trunck either of the vena Cava, or vena Portæ, into the Liver; and ſo rinſe out the blood remaining in the veſſels and ſubſtance thereof; you ſhall ſenſibly perceive the redneſs of the Liver to vaniſh away, and a certain duskiſh or ſooty yellowneſſe ſucceed in

exercit. de gen. Animal. 51 ſub finem.

the room. Which obscure yellownesse, doubtlesse, hath its original meerly from the tincture of Choler. However, most certain it is, that the Liver hath natively no redness at all; and what it afterward contracteth, is adventitious, and from the blood. To this purpose is that easie experiment of Dr. Harvey; *imò verò jecur, lien, renes, pulmo, & cor ipsum (si sanguinem inde omnem expresseris, cujus præcipuè gratia viscera dicuntur) expallescunt illicò, & partibus frigidis accensenda sunt.* So that we may with good warrant conclude, that the office of Sanguification was, by the Galenists, assigned to the Liver, rather upon inconsiderate partiality, than any right at all.

Loco jam citato.

(2) Of the *veins* also the same may be said. For, if that rule of *Galen* holds true (as certainly it doth); *Quod mutatur, in ejus speciem, à quo mutatur, facessit*; the veins can never be thought fit, to transform the Chyle into blood. For, their Colour is white and somewhat translucid; their substance viscid, membranous, and bloodless; they have no parenchyma, and very little either of heat or spirits of their own: whereas, on the contrary, the Blood is of a deep red, not translucid, of a substance fluid and interminate, and abounds with heat and spirits. And, therefore, it were vain to expect an Assimilation, where the supposed Agent and Patient are of natures in all things so incompatible, so contrary. We deny not, that the veins in some respect conduce to the *Conservation* of the blood; but how? Only as they are

4. Nor the veins.

are Organs, inservient to the defence of it from external injuries, and the reduction of it from the parts upon which it was newly affused out of the arteries. And as for any similar Action of the veins upon the blood; they have none at all: yea, their office of Conserving it doth consist chiefly in their inactivity, *i.e.* in this, that they are not apt to alter or deprave it; as Glass-vessells are the best to conserve liquors in, because they neither communicate any ill qualities of their own, nor permit the like to be communicated from others to them. But, that which doth principally conserve the blood in the purity of its nature, is the very same thing that makes it from the beginning, *viz.* the *vital Heat and Spirits derived from the Heart*, which by their enlivening warmth, and continuall motion, do not only vindicate the blood from corruption, but also all the solid parts of the body, and so even the veins themselves also, as long as the Lamp of life continueth burning. And that being once extinguished; how soon, alas! do all parts of the body yeeld to the quick tyranny of corruption?

5. Nor the *Heart*: but the *vital spirit*, residing in the blood.

(3) Nor hath the Heart more right to this noble office of Sanguification. For, that borrowes all its vital heat and activity meerly from the vital blood contained in its ventricles, and distributed into its substance by the Coronary arteries. Of which vital influx were the Heart deprived, but for some few moments; it would soon become as torpid and motionless, as any other part of the whole body; so far

far is it from exalting the Chyle into so noble a Nectar, as the blood is, by any similar action of its owne. To assure this, please you, take out the yet-panting Heart of any the strongest and soundest Animal, and having with warm water rinsed all the blood out of the ventricles, fill them again with warm Chyle or Milk; and see whether it will be able to convert the same into blood. Certainly, you shall find none the least change to be wrought upon the liquor infused. Yet the Heart is a solid and strong part; and one would scarce think it probable, that that action, which it is supposed to performe, by reason of its solid substance, should be intercepted in so short a space of time. Forasmuch, therefore, as the Heart doth, in a moments time, surcease its activity, and desist from the work of changing Chyle into blood, as soon as the vital blood is effused out of its ventricles; it is as manifest, as certain, that the virtue Generative of blood, is not radicated in the solid substance of the Heart, primarily, but in somthing else, *viz.* in that very thing, upon whose absence immediately that virtue is destroyed, which is the vital Blood. Again, the dissection of Living Animals teacheth us, that the vital Heat is much greater in the ventricles, than in the substance of the Heart: and Reason biddeth us thence to inferr, that the same Heat is originally in the ventricles, and but at second hand, or by way of communication, in the parenchyma. Now, if the Activity of even the Heart it self, be derived

rived originally from the vital Blood; and that the vital Blood be more powerfull than the Heart: we can hardly deny the ſame to be the Primary Cauſe, or Agent of Sanguification; unleſs (at leaſt) it ſhall appear, that the vital blood is leſs apt for ſuch a work, than the Heart. But, comparing the agreeableneſs of the Heart to ſuch an office, with that of the vital Blood to the ſame; we ſhall quickly perceive which of the two hath the greater. For, the vital Blood is of the ſame ſpecies with the thing to be made or produced; but the ſubſtance of the Heart is far different from it. It being, therefore, canonical, that all Naturall Agents endeavour, according to their energy, to aſſimilate to their own nature the thing, upon which they act: it ſeems of equal certainty, that the activity of the vital Blood, is moſt properly conſigned to the work of Sanguification. A further evidence of this, may be drawn from hence, that the Chyle and Blood are moſt *intimately mixed* together in the ventricles of the Heart; while the Chyle doth only *ſuperficially* and *in tranſitu* touch the ſides of them. To which may be added, that the Chyle makes but a very ſhort ſtay in the Heart: but remains conſtantly commixed with the Blood, untill it be thereto perfectly aſſimilated. Laſtly, the blood flowing in the heart, arteries, and veins, doth exceed the Chyle of one meal, in quantity at leaſt ten times, and in ſtrength or activity, an hundred; (for, what is more potent, then that ſpirit, which enliveneth the whole body;

what

what ſofter, gentler, and more eaſily ſuperable, than Chyle ?) and therefore, no doubt but the Bloud doth eaſily obtain the victory over the Chyle, and over-run it with his own nature.

7. which alone formeth the blood in a chicken, out of the *Colliquamentum.*

To ſecure this Aſſertion from all doubt whatever, let us have recourſe to the obſervations of *Dr. HARVEY* (the true Oedipus in all abſtruſities of this kind) of the progreſs of Nature in the generation of the parts of an Animal ſucceſſively one after another; and we ſhall ſoon be ſatisfied, that the Firſt Bloud is made by the vital ſpirit. That great man atteſteth, that the white of the Egge doth for ſome dayes after the Hen hath ſat a-brood upon it, retain its native whiteneſſe, and that out of the Colliquament, or White, made more thin and fluid, the Chick is generated, without the addition of any other matter. The Queſtion then is only this, *How that white colour in the Colliquamentum, or ſo much of it as the Plaſtique faculty converts into blood; comes to be changed into red?*

Certain it is, this cannot be effected by any thing that was red before; becauſe there is no part of the Egge of, or inclining to, that colour; and the yelk remains intire a good while after there is bloud to be ſeen in the *punctum ſaliens.* Nor is it the Fleſhy parts, that communicate this vermillion tincture to the bloud, becauſe they remain white after the bloud is made out of the Colliquamentum: and it is much more reaſonable, that the fleſhy parts derive

derive their redneſſe wholly from the bloud, perpetually irrigating and waſhing them in its Circulation. For, their redneſſe grows upon them by degrees, and that ſooner or later, according to the degrees of Heat impreſſed upon the Egge by the Hen, and according to the greater or leſſe quantity of bloud arriving at them. Some parts, which are but lightly touched by the bloud, never become red; in which account are the coats of the Eyes, the Ligaments, Tendons, Membranes, Bones, *&c.* Others obtain a certain paleneſſe daſhed with a ſparing mixture of red; as the Glandules which as they are furniſhed with greater or ſmaller arteries (reſpective to their magnitude) ſo are they tinged with more or leſſe of redneſſe. The Muſculous fleſh is more deeply died with ſcarlet, than the Glandules; as being irrigated with greater ſtreames of bloud. The Kidneys, Liver, Spleen, Lungs, and Heart, are all waſhed with full ſtreams of bloud; and therefore have a deeper dye of redneſſe, than any other parts: and yet are much leſſe red, than the bloud itſelf. Now it is more reaſonable to conceive, that the Greater ſhould communicate its virtue to the Leſſer, than on the contrary, the Leſſer to the Greater. For, how can any Natural Agent operate beyond the ſphere of its activity, *i.e.* the meaſure of its power? or communicate that to another, which it ſelf wanteth? Again, nothing can have an activity, before it hath a beeing: and conſequently the ſolid parts cannot give a red-

neſſe to the bloud, becauſe they are not in beeing, till after the bloud. Nothing, therefore, remains to be the Efficient of the Bloud, but the *Vital Spirit*, kindled originally in the pureſt part of the ſeminal matter, or *Colliquamentum* which we may well denominate the *Vital Liquor*.

8. The *Manner* how bloud is firſt generated in an *Embryo*, by that *Vital Spirit*.

Concerning the *THIRD* conſiderable, *viz.* the *Manner* of this grand operation of the Vital Spirit; though it be very obſcure, yet doe we not think it altogether inexplicable, if we deduce the bloud from its firſt Origine, the newly mentioned *Vital Liquor*. This *Vital Liquor*, before it aſſumes the colour and forme of Bloud, doth begin to ſeparate it ſelf from the other parts of the Egge (to which it is at firſt promiſcuouſly admixed) and to runne its ſelfe out into certain ſlender rivulets, or branchings, which afterward become Veins. Theſe rivolets concurring in a point, meet altogether at the centre of the *Colliquamentum*; which centre being the principal ſeat of the Plaſtique ſpirit, and acquiring a certain mication, or pulſation, is then called *Punctum Saliens*? And all this is done, before there is any the leaſt appearance of bloud in the Egge. So ſoon, therefore, as theſe Rivulets are conjoyned, the Flux of the *Vital Liquor* is, for ſome time, ſo hindred by, and repreſsed in them, as that being indeſinently agitated by the *Spirit of Life*, it æſtuateth, and indeavours to expand it ſelf and enlarge its bounds: and ſeeing that it cannot flow back againe toward the circumfe-

rence,

rence, by the same passages, which brought it toward the centre, by reason of fresh supplies of *Vital Liquor* pressing it forward continually in the course begun; it is compelled to force it self again into the seminal matter, from whence at first it began its motion, through other slender conduits newly for that purpose formed, and then it begins to flow in a round. For, this appears to be the true reason of the *Circumgyration* of the *Vital Liquor*, from the very beginning. Soon after this, the Rivulets or pipes first made, and leading from the circumference to the Centre, become *Veins*; and the others made in the second place, and leading from the centre to the cicumference, become *Arteries*: which yet others disallow, in respect of the fabrick of the valves) and then in the poynt of their concourse or confluence, the *Heart* is framed. Through which Heart, and the conduits annexed or (rather) continued unto it, the one sort tending toward, the other from-ward the centre; the *Vital Liquor* doth (while life lasteth) perpetuate its motion: and at the same time irrigate and vivifie all parts of the matter, which it continually washeth in that its circular course. Now this *Circulation* is begun, for some time before the Vital Liquor is excocted into bloud; as may be conceived from hence, that when the motion of the *Punctum Saliens* is plainly visible, there is no bloud, but only a clear, transparent liquor, or (as the Learned *Harvey* call's it) the *Colliquamentum*: and also from hence, that while

the *Seminal Matter* is yet thin and fluid, the Vital Liquor can easily disperse its channels through the same; there being then no impediment to that its expansive motion, and operation: but, if it should defer its dispersion and making of rivulets, til after the solid parts were made; 'tis hard to conceive, how it could be able to shoot it self forth into branches, and make its way through them.

9. and in what part of the Conception it is first generated, viz in the *Chorion*.

This *Dance of Life* being thus begun, though no Bloud yet appears, yet soon after it doth appear; the Vital Liquor, while continually (though slowly) circulated, by little and little assuming the form of Bloud. And the place in which the bloud first shews it selfe, is the *Chorion*; not the Heart. For, seeing that the *Chorion* ought to be made solid and firme, before any other of the parts of the Conception, insomuch as it serveth as well for the safeguard, as nourishment of all the other parts; and that to this end, there is no moysture comming from without, that might hinder its being made solid; and that the Chorion, as involving the whole conception, is the first part that receiveth the warmth of the Hen, during her incubation: we say, from hence it comes, that the vital Liquor doth first of all obtain the forme of Bloud in the Chorion. And this is effected the sooner, because the vital Liquor doth more easily emit its exhalations, in that place, as being in the circumference, than in any other more remote from it: and unlesse those exhalations were freely emitted, the

Spirits

Spirits of the *Vitall Liquor* would inevitably be soon extinguished. It is moreover probable, that at this time, the Vital Heat is more potent and active in the exteriour parts of the Conception, than in the Centre; and so, that the First Bloud is made in the Chorion, where it first discovers it self to the sight of the inspector. Hence also we may observe, that because there is no bloud to be discerned in the *Punctum Saliens*, for many hours together after bloud is discernable in the *Chorion*: therefore, must the Circulation of the bloud be exceeding slow in the begining; for, as soon as the bloud, that is in the *Chorion*, performing its circular motion, arriveth at the Heart, it cannot but be discerned in the *Punctum Saliens*.

10. In the generation of Blood, what are the Concurrent Extrinsecal Causes: and what the Accessary Organical.

Now, these observations being undeniable, we may safely assert; that the *Vital Spirit* in the *Seminal matter*, being excited and assisted by the external heat of the Hen sitting upon the Egge; and by degrees becoming active, and infusing heat into the vital Liquor, wherein it doth reside: doth thereupon, in processe of time, induce the colour of bloud; and that only by means of its vital Heat and Motion; and that no other part is to be reputed for Principal Agent, in the work of Sanguification. Nevertheless, we do not hereby exclude *Concurrent extrinsecal Agents*, or *Causes*: but into that account readily admit the Hen, whose warmth at first both excited and assisted the Vital Spirit in the work of Sanguification; and the

the substance of the Heart itself, which afterward conduceth in some sort to the same. Nor do we repudiate *Accessory Organical Causes*; as the *Fabrick of the Heart*, the *Arteries* and *Veins*, all which are inservient to the continual motion of the bloud. Only we affirme, that *the Vital spirit, by reason of its Heat and Motion, hath a just right to the dignity of Principal Agent, in making of Blood.*

11. The Conversion of the *Colliquamentum* into Bloud, by the heat and motion of the Vitall Spirit; illustrated by sundry analogous *Experiments*, and *Observations.*

We say, *By reason of its Heat and motion.* For, that Colours frequently are advanced from a white, or pale, to several kinds of Red, meerly by Heat and Motion; is demonstrable by sundry easie and familiar Experiments. Our Confectioners well know, that long boyling of Quinces and other Fruits doth give them a ruddy colour. So likewise Fruits baked in an oven, are more inclined to redness, than while they were raw. The same is true also even of Flesh, and Bread, which by baking or rosting, acquire redness in their superficial parts: and some Chymists affirme, that a Tincture of Bread will assume a certain degree of redness, after long digestion. This is not, we acknowledge, common to all Liquors, especially simple ones; for simple waters, and such as are destilled, suffer little or no change of colour, upon decoction, though long. But generally all Compound Liquors, especially if they contain any Nutritive juice, in competent quantity, and have besides any touch of salt, or Acid spirits in them: are observed to acquire a sanguine tincture, by decoction. Upon which fertile hint,

as

as we conjecture, that highly Learned, Industrious, and Acute Person, Dr. ENT, seems to have grounded that ingenious opinion of his; that the Redness of the Blood ariseth *ex Acidi-tate spiritus vitalis salinei*, from the *Acidity of the vital spirits*, having their original from a certain seminal salt. However, we have good reason to perswade our selves, that all *vital Liquors*, *i.e*, such wherein the vital spirits of Animals do reside, are apt to acquire more or less of redness; provided they obtain sufficient Heat, and agitation or strife in their motions. This is evident in all Sanguineous Animals, in which the Chyle is first white, and after changeth into bloud. And as for Exsanguious Animals, they also give some testimony of this truth; as may be instanced in Oysters, in which bloud is frequently found (and yet without a prodigy) in summer time, by reason their vital Heat seems then to be augmented: and in winter, when their Heat is again lessened, below what is requisite to induce redness, their vital juice is alwayes whitish. To return to sanguineous Animals; as they are generally hotter of constitution, than Exsanguious; so are their Sanguine parts alwayes hotter, than their pale and white parts. In like manner, in cold diseases, as the Green sickness, Cachexy, Dropsy, and in all Phlegmatique constitutions, the bloud is paler, than in hot diseases and constitutions. Again, the venal blood, as it loseth the heat, which it had acquired in passing through the heart and arteries; so doth it propor-

in Apolog. pro circulatione sanguinis, adverſ. Parisan. p. 119.

proportionately by little and little lose that florid and deep scarlet dye, that it had in the heart and arteries. For, blood let forth of a vein, appears blewish, and comes short of that lively fresh scarlet, that is observed in bloud effluxed from an Artery. All which clearly shew, by whose efficiency it is, that the vital juice (in Sanguineous Animals) is excocted into Bloud; and what conserves the same in its primitive purity and lustre: *viz.* the *vital spirit* continually renewed in, and enlivening the blood; for, that being once extinguished, how soon doth the bloud degenerate into *Cruor*, and lose its fresh scarlet tincture?

12. That the same *Agent*, which maketh the first blood in an *Embryo*, doth make it ever after in an *Animal*, during life.

Having thus investigated what that is, which makes the *First* Bloud in an Embryo, by converting the *vital Liquor*, from a white, into a purple Nectar: we cannot be long in exploring what that is, which in *Animals* maketh bloud all the life after, by converting the *Chyle* likewise, from a white into a red liquor. It is an infallible rule, you know, that the *identity of Effects dependeth upon the identity of Causes*; because an effect is not supposed to be, untill it hath obtained existence from its proper causes: and at the same time the causes give that existence, they cannot but give also the identity belonging to it. All which is imported in that common Axiome, *Idem, quà idem, semper facit idem.* For, though *Free* and *Arbitrary* Causes may act at liberty, and, by varying the manner of their operating, vary also their effects: yet *Natural* ones are bound up to a determinate mode

mode of energie, and must, as long as they continue the same, act after one and the same way, and so produce invariably the same effects. Forasmuch, therefore, as the Efficient of the First Blood, is an Agent *Natural*, and not Arbitrary; if it continue the same in an Animal, while the Animal lives, it must of necessity continue the same operation. That it doth continue the very same, during life, is most certain; because it is the Principle of life, nor can life subsist for so much as one moment without it. Nor doth this Efficient of Bloud only persist the same in the body, that it was at the first conception; but growes every day more vigorous, potent and fit for the work, untill the Animal hath attained to the flower of his age: and to imagine that an Agent Natural (such as the Vital Spirit) should at any time become idle, intermit its operation, and not exercise all its forces; is grossely absurd. Conclude we therefore, that the Vital Spirit, as it is the Efficient Cause of Sanguification, in the Embryo from the first Conception; so is it constantly Author of the same work, untill the Animal dieth.

OF THE USES OF THE BLOOD.

Exercitation the Fifth.

Article. 1. That the Bloud is not the General Nourishment of the body. Because

IT followeth now, that we enquire, *To what End Nature* hath consigned so continuall a province, as this of Sanguification, to that subtile Agent, the Vital Spirit; or, more plainly, of what *Use* the Bloud is, in Sanguineous Animals. Concerning this, there are (for ought we know) but *Two opinions* extant; the *One*, that *the Blood is the general Nutriment of the body*, or Matter by which the substance of the parts is daily instaurated; the *Other*, that *it serveth both for the maintenance of the vital Flame, which cannot subsist without a perpetual supply of convenient fewell; and for the refection of vital spirits.* The *Former*, though very antient, and generally embraced; yet (in our judgment) deserveth to give place to the *Latter*: because though the Latter be new, and as it were of but yesterdayes standing, yet it hath much more of probability, as may be evinced by these ensuing Arguments.

2. The contrary opinion is subject to sundry both inexplicable difficulties, and irreconcileable incongruities.

(1) It is well known, that *Aristotle*, in many places of his works, hath earnestly contended, *Sanguinem esse ultimum totius corporis alimentum*, that the bloud is the ultimate, or most perfect Aliment of the whole body: and that the whole School of *Physicians* hath given its suffrage

frage to verifie that his Tenent. And yet many things, not easie to be explicated, and lesse easie to be reconciled one to another, may be observed to attend thereupon. For, *Physicians*, when, in their Physiological discourses, they treat of the nature of the Bloud and endeavour to make good, that it serveth to no other use, but only to afford Nutriment to the body; they suppose it to be a substance, not simple and homogeneous, but mixt and compounded of Four several juices, promiscuously flowing together in the same streams: deducing their principal argument hereof, from the Combinations of the Four First Elementary Qualities (as they call them) and accordingly teaching, that the ingredients of bloud are the two sorts of *Bile*, or *Choler* (*viz.* the yellow, and the blackish) *Phlegme*, and *Blood* properly so called. Further, of each of these different humours, They make some *Nutritive* (as assuming the whole body to be made up of them) others *Excrementitious*: and then They decree, that the bloud doth consist of those diverse Nutritious humors, as of Heterogeneous parts. After, though they allow the Phlegme to be the colder and cruder part, and so capable of conversion into good and laudable blood, by more intense heat, and longer concoction; and likewise allow the Choler to be convertible into Melancholy, by adustion; and blood to be convertible into both choler and melancholy, by the same means: yet will they by no means admit of a regression of either Choler or Melancholy

into blood. Now, if these things be true (as may well be doubted) and that there is no possible regresse of Melancholy into Choler, nor of Choler into laudable Blood: then will it inevitably follow, that all the other three juices are but only in Order to Melancholy: and that Melancholy is the principall and most perfectly concocted Aliment. Nay more, They must grant two sorts of Blood; the one, the whole masse of blood contained in the veines, and composed of those four humours: The other, the more pure, more florid, and more spiritual part thereof, which in a stricter sense they call blood, and which some will have to be contained only in the heart and arteries, apart from the venous blood, as deputed to peculiar and more noble Uses. Now, according to this distinction, it is manifest, that not the pure arteriall bloud is the nourishment of the body, but the baser, composed of diverse juices, or rather chiefly the Melancholy; to which as to their ultimate term, or perfection the three others tend. And how incongruous it is, to conceive, that the body is nourished, either with impure juices, or with Melancholy a cold dry and earthly humour as they define it: is obvious to men of even the shallowest understandings.

3. There are sundry parts, into whose substance the blood is not admitted.

(2) If the Blood were the Universal Aliment of the body, then certainly no part could be nourished, at which the blood doth not arrive: but we see that many parts are nourished, as the Brain, Bones, Nerves, Ligaments, Testicles,

Testicles, &c. to which notwithstanding the blood is not so brought, as to be admitted into their substance: and therefore the blood is not the Universal Nourishment. We say, so as to be admitted into their very substance; for though blood be found in those parts, yet doth it not penetrate deeply into them, as the Nutritive juice ought to do: *alimenti enim vis* (saith *Hippocrates*) *ad ossa usque pervenit, & ossium partes.* The blood doth, indeed, touch upon those parts, in its running round the body; and but only touch them; and for this reason, that all the parts may be cherished and enlivened by the Vitall Spirits, which it carrieth along with it. Thus, in the Brain, veins are no where found, but disseminated upon the Membranes, that are their support; the *Plexus Choroides* and some other few places excepted. Which perhaps is the reason, why *Aristotle* denyed any blood to be contained in the brain; because it is not effused into the substance thereof, as it is into the fleshy or musculous parts.

lib. de Alimento.

1 Hist. an. c. 16.

(3) Men that are fat and plump, have but little blood; and such as are spare and lean, have abundance: which could not be, if blood were matter of nourishment. And because Lean persons have much blood; therefore are they more lively, couragious, and active, as abounding with Spirits, in proportion to their great quantity of blood. Hence is it also, that Lean persons bear large evacuation of blood, without detriment of health; because their fleshy

4. Fat men generally have the least blood, and Lean the most.

fleshy and musculous parts, as being firme and solid, drink up the least quantity of bloud in their pores, and so there remains the more for the fewel of the Vitall Lamp. Whereas, on the contrary, grosse and fat persons, suffer great dammage by large effusion of bloud; because the habit of their bodies being despoyled of Spirits and hotter bloud, is filled with serous humours, and so easily degenerateth into a Cachexy. In like manner, in a gross body, where are more parts to be nourished, there ought to be the more bloud to nourish them: but grosse men, for the most part, eate much lesse, than lean; because they have lesse veins, and being inclined to sedentary and unactive lives, they consume but few Spirits. For it is but a small portion of the Chyle, that is, converted into the *Succus Nutritius* (the dissipation of the substance of the parts, being neither so suddain, nor great, as hath been vulgarly conceived, as we formerly explicated) and the rest, after its unprofitable parts are separated, being brought to the heart, is mostly consumed in Spirits. Such things, therefore, as relieve the Spirits, suddainly satisfie our hunger; as good wine. Whence that Aphorism of *Hippocrates*; *Famem, vini potio solvit*: because vvine revives the Spirits.

2 Sect. Aph. 36.

5. Men perishing by famine, have their arteries and veins full of bloud.

(4) In Animals dying of famine, and men dying of Consumptions; good store of bloud hath been found in the veines and arteries. Which were impossible if bloud were the nourishment of the body: for, then no Animal could

could perish by famine, while it had any bloud in its vessels: nor could the body be so emaciated, in consumptions, while the veins contain so plentifull a source for the resarcition of the parts. Which reason, among others, induced *Dr. Harvey*, to conclude; *etsi sanguis sit pars corporis, non tamen huic nutriendo solum destinatur. Enimvero, si huic duntaxat usui inserviret, nemo fame periret, quamdiu sanguinis quicquam in venis reliquum habetur: quemadmodum & lucernæ flammula non extinguitur, quamdiu inflammabilis olei in eâ vel minimum suppetit.* *de gener. Animal exercit. 52.*

(5) If the bloud were changed into *Ros & Cambium*, as they call them; then, certainely, in the habit of the body, and capillary veines, it would appear white, or inclining to whiteness: but our sense assureth, that it is no less red and florid in those places, than in the centrall parts of the body. 6. The bloud continueth red and florid, in the habit of the body.

(6) *Hippocrates* hath a singular observation, of a certain man, a patient of his, who being much emaciated, and every day more and more consuming, notwithstanding the most restorative aliment he could take; was at length cured, only by a very profuse eduction of bloud out of the veins of each arme, after all other means had been in vain attempted. Which would not have hapned, if the bloud were the nutriment of the parts. The reason of this admirable cure seems to be this. There is (as we have more than once declared) a twofold expence of the Chyle: one part goes to the instauration *libr. 5. Epidem. t. 25.* 7. *Hippocrates* cured a man of extream Leanness, only by profuse Phlebotomy.

ſtauration of the parts, as being, or conſtituting the *Succus Nutritius*; the other ſupplyes the Vitall Spirits, under the form of blood. Now when one of theſe exceeds, the other languiſhes; and the too plentifull exhauſtion of the Chyle, upon the blood being the cauſe of this mans Leanneſſe, his recovery ſucceeded upon a turning of the ſtreame of the Chyle upon the parts for their ſufficient Nutritive juice.

8. The blood is obſerved to be leſs unctuous and glutinous, in the Arteries, that carry it to the parts; than in the veins, that return it from them.

(7) If the blood did nouriſh; then would Fat, unctuous, and glutinous blood be moſt accommodate to that uſe: for, the ſerum hinders the appoſition of the blood, and therefore Ichorous and weeping Ulcers are ſeldome conſolidated. Now, the blood is obſerved to be more unctuous and glutinous in the veines, than in the arteries, in which it is commonly more diluted, and full of ſerum: but the blood is carried to the habit of the body by the arteries, and from thence brought back again by the veines. Which, certainely, is a very weighty argument, againſt the Blood's being the nouriſhment.

9. There is a manifeſt *Diſſimilitude* betwixt the blood, and ſundry parts of the body.

(8) Betwixt the thing nouriſhed, and its nutriment, there ought to be a certain Analogy, or ſimilitude; according to that old ſaying, *Partes quaslibet alimento ipſis maximè conſimili enutriri*: but betwixt the blood and ſeverall parts of the body, inſtead of this requiſite reſemblance or affinity of qualities, there is in many things a perfect Diſſimilitude or diſparity. For, if we compare the blood, with the brain,

brain, the Horny coat, or Humors of the Eyes, the Bones, tendons, and other the like parts, we shall find little or no proportion, or resemblance betwixt them. In an Appolexy, where the brain is overflowed with bloud effused into the substance of it, all the ideas or marks of things formerly known, are quite obliterated, nor doth any perception of them remain. Likewise when the eye is bloud-shodden, the perspicuity of the coats of the eye is changed into opacity, and the transmission of the visible species through them hindered. The bones also are so many wayes discrepant from the bloud, that it seems impossible they should be constituted thereof. And of the tendons, Nervs, membranes, *&c.* the same may be said.

10. The progress of Nutrition, is from crudity, to fusion and volatility; not retrograde from volatility to fixation: and so the Aliment ought to be more crude, or fixed, than the parts to be nourished.

(9) The Manner of Nutrition, is a certain promotion of the aliment from the state of crudity; to the state of concoction, or an Exaltation of its Spirits to a further degree of activity. And therefore, the aliment must of necessity be more crude, than the part therewith nourished. For, that promotion is not by any degradation, or Fixation of the Spirits of the aliment; but by an Exaltation or reduction of them neerer to volatility. Forasmuch therefore, as the Spirits already in the bloud, are approached or advanced neerer to the state of volatility, than those contained in the parts above mentioned: certainly, the bloud cannot be thought a convenient nourishment for them. The redintegration of those parts ought

to be expected from such nutriment, as is more fixed than themselves are: Otherwise how could it suffice to the solidation or firmation of them? But, the blood is of a more rough and grating nature, and its spirits more advanced toward volatility, than those residing in the solid parts: and in that respect is wholly unfit to nourish them. Moreover, it is necessary, the Nutritive juice should be sequestred from the blood, before it can be opportunely broughtand apponed to the parts: if so, to what end was it admixt to the blood at all? shall we believe, that Nature (rather than seem idle) doth make any thing, only that she may unmake it again afterward?

11. The blood is it self nourished, and doth consume the substance of the solid parts: and so cannot be their nourishment.

(10) What is it selfe nourished, cannot (without absurdity) be thought to be the nourishment of another: nor can that which is the cause of the exhaustion of the solid parts, be the matter of their redintegration. That the blood is it self nourished, is manifest from the large access of Chyle to it, after every meal: and that it is the cause of the exhaustion of the solid parts, is also manifest from hence, that the Vital Heat, whose *subjectum inhæsionis* is the blood, is the only consumer or depredator of the solid substance of the body. For, whatever be the effects of the Vital Heat, residing in the blood, as its proper and original subject; the very same may be justly imputed also to the Blood itself. For, albeit we sometimes ascribe the actions of things to their Qualities, or Faculties; thereby indicating the

Formal

Formal Reason, or Manner; by which the substance operateth: yet we cannot deny, but it is the very substance it self, to which those Qualities are inherent, that really performeth the action. It is the blood it self, therefore, which by reason of its inherent Heat, doth uncessantly prey upon the substance of the solid parts, and causeth them to make provision for their reparation, even after they have attained to their perfect magnitude. Nor doth it only so, but it moreover, in case of famine, converts the solid substance of the parts into its own, supplying its defects out of their decayes. This is manifest, in long abstinence from meat, when though the habit of the body be extenuated, yet (provided the person take water, or some other thin liquor, that may be a vehicle of the Humours) do the arteries and veins continue full of bloud. Thus also in Fevers, though the stomack be so weake, as to abhorr all things but small beer, or cooling Juleps; yet doth the blood all that while repair it self, by colliquating the substance of the solid parts, and converting it into its own. For, how otherwise could the streams of blood be dayly replenished? And, that they are replenished, is evident from hence, that though the quantity of blood be diminished (proportionately to the strength of the patient) by Phlebotomy, in the beginning of the Fever: yet will it be again, in a day or two after, so encreased, as to require a second, and perhaps a third diminution; and that, notwithstanding the sick person hath

received little or no nourishment all that while. An undeniable argument, that the bloud, in that defect of supplies from the Chyle, doth repair it self out of the spoils of the solid parts. Now, since the bloud doth exhaust and depredate the solid parts; how can it consist with reason, that it should be their nourishment?

12. The First Matter, of which the parts are made, is not Blood; but a certain liquid juice, very like the white of an Egge.

(11) The Aliment of the parts ought to be in all things like that matter, of which they were at first composed. For, what is superadded to the parts, as they are augmented, is of similar substance with that, which was præexistent in them, and so of necessity must be constituted *ex congenere materia*. Now, the *Materia prima* of all the parts, is not bloud, but a certain liquid juice, perfectly resembling the White of an Egg, of which the Chicken is formed; only with this difference, that in viviparous Animals that Liquor is more thin, and like the *Colliquamentum* in Eggs, after the Hen hath sitten upon them some days. For even Viviparous Animals conceive a kind of Egg in their wombs, which is involved in a thin membrane, and containeth a certain viscid humour, very like the White of Eggs, attenuated and melted by the warmth of the Hens incubation. And this Liquor is the very matter of which the Embryo is first formed: but very unlike the bloud, in substance, colour, and all other qualities. As therefore the parts are not made up of bloud, at first; so are they not augmented or nourished by it afterward.

We

We said, That the bloud is not the *General Nutriment* of all the body; thereby admitting, that it may be the *Particular* nutriment of some parts. For, as to the *Parenchymata Sanguinea*, the parts whose substance is chiefly Sanguineous; forasmuch as they seem to consist mostly of the thicker parts of bloud coagulated in them, and affixt to their vessels and fibers; and that they have no Nervs derived unto them, through which the *Succus Nutritius* might be imported into them: we conceive, that the decay of their sanguineous particles, is dayly repaired by the fresh opposition and affixation of the like particles of the bloud. And in this accompt, we reckon the *Liver, Spleen, Kidneys, Heart, Lungs*, and *red parts of the Muscles*. Yet in all these, whatsoever of *Fibers, Membranes, or Vessels*, is found commixt with their *Parenchyma* or Sanguineous substance; all that is to be excluded from the capacity of being nourished by the bloud. But, as for all the Fibrous, Membranous, and Nervous parts of the body, and all the *Parenchymata Sanguinea*, as the Brain, Spinal Marrow, the Humours of the Eyes, Teeth, Bones, and Glandules; it is most probable (from the reasons alleadged) that they are nourished, not by the bloud, but by some sweeter, softer, and milder liquor, congenerous to the spermatick matter, or *Colliquamentum*, of which they are originally constituted; which is dayly brought and effused or instilled into their substance, out of the Nervs inserted into them. But of this distribution of

13. Nevertheless the blood may be the Nourishment of such parts, whose substance is mostly sanguineous: and what those are.

of the *Succus Nutritius*, by the *Nervus*, we shall have opportunity to discourse more particularly hereafter.

14. The manner, how the *Vital Heat* is conserved; and the *Vital Spirits* continually recruited, *ex sanguine.*

VVell then, of what Use is the bloud? Why truly (according to the latter opinion recited) we conceive it to serve both as the Pabulum, or Fewel of the Vital Flame, and as the Matter of which the Spirits Vital are confected. Concerning the manner, how Flame is maintained by its Fewel; we have already plainly, though succinctly, discoursed. And, as for the Manner *how the Vitall Spirits are continually recruited, ex Sanguine*; we may understand it to be thus. The Spirits, contained in our solid aliment, being at their first admission into the stomach, crude or in the state of *Fixation*; are soon after, partly by admistion of Liquids, and partly by Fermentation, promoted, from the state of *Fixation*, to that of *Fusion*. In this state, the richer or more nutritive parts of the solid aliment, being, by way of Liquation, throughly commixed with the drink; there resulteth a certain milky juice, called the *Chyle*; which is a Liquor abounding with sweet, mild and delicate Spirits. Now these Spirits, so soon as they are brought to the Heart, and there commixt with the Vitall blood; are by little and little exalted to a third state, *viz.* that of *Volatility*; and so become fit subjects to entertain the Vitall Heat, and want only another recourse to the heart, to be therein, as it were by accension, advanced to the heighth and dignity of perfect vitall Spirits. For, the

Vital

Vitall Spirits differ from the Spirits contained in our aliment, no otherwise than in the gradual preparations and exaltations now mentioned. We are to advertise moreover, that the Heart, in its Systole, is not contracted so closely or streightly, as to expell all the blood contained in its Ventricles, at once: but leaves a good part thereof remaining in them, after the contraction is ended. And that this remaining blood doth heat and kindle the portion of blood next effused out of the veins into those ventricles; and by that means exalt it to the condition of Vital blood. We further observe, that in the Spirits of the blood, there are sundry degrees of volatility; so that some attain to the highest degree of volatility much sooner, than others; and none, untill they have undergone severall Circulations, and as many fresh Accensions in the Heart. For, in every Circulation they grow more and more subtile and agile; and so must at length be brought to the requisite height of volatility. To which having once attained, in the very next Circulation (though they are restrained and kept in, by the sides of the heart, and coats of the arteries, while they remain therein) being diffused upon the outward parts of the body, as they warm and vivify those parts, so do they soon flye away, and disperse themselves into air. And while these thus flye away, other Spirits lesse volatile are, by the colder temperament of the parts, by which they pass, somewhat repressed: so that the force of their expansive

pansive motion is much abated, the Mication or panting of the bloud interrupted, and the bloud wherein they are, of Arterial, or vital bloud, is made venouse or Natural; and such it continueth, untill the next circulation bring it again to the heart, there to be kindled afresh, and exalted to the due heat of vitality. Which once acquired, it recovers its intermitted motion of Mication, or rising and falling alternately, and yeeldeth a fresh supply of spirits vital; which being transmitted to the habit of the body, are soon dispersed, like the former.

15. The Reason of the *Mication*, or panting motion of the Blood, in the arteries.

And thus is the vital Flame kept alive, at no lesse expence, than a continual dissipation of the most votatile spirits of the blood. For, that vital Heat ariseth from within, and the most subtile spirits are the first Movers to the excitement thereof: the motion by which they do it, being their indeavour to expand themselves, and to dilate their bounds, while the other grosser elements, or ingredients of the bloud, oppose them therein. And this *Strife*, or *Counter-activity* of the spirits, on one part, and of the grosser ingredients of the blood, on the other, doth exhibite the *general Essence of Heat*. To which may be added this short observation, that in this Contention, one while the spirits prevailing, do lift up, or swell the mass of bloud; another while the grosser elements (the contraction of the Heart and arteries assisting them) prevailing, countermand and interrupt that expansive motion: and that by

this

this alternate conquest of these Antagonists, is made the *Mication* or *Rising and Falling of* the blood, the one in the Dilatation, the other in the Contraction of the Heart and arteries. Forasmuch, therefore, as the vital Heat doth consist in the rarefactive motion of the spirits, and the renitence of the grosser parts of the bloud; and that the spirits, for the most part, at least alternately, obtain the victory and dominion over their opponents: it seems most consentaneous to truth, that *this vital Heat cannot be preserved, without a perpetual expence of the most pure, i. e. the most volatile spirits of the blood*; and consequently necessary, that during life, *fresh spirits must be perpetually minted out of the blood*, to defray that vast and continual expence. And this we conceive to be the true progress of Nature, from the first reception of the spirits contained in the Aliment, to their eduction into the Chyle, their sublimation in the heart, their gradual exaltation to the highest degree of volatility, and lastly their dissipation through the skin into aer: upon which depends the Conservation of the vital Heat, and the continual Generation of the vital Spirits.

OF THE MOTION OF THE BLOOD; ITS CONDITIONS AND CAUSES.

Exercitation the Sixth.

Of the Motion of the Blood, its Conditions and Causes.

1. The Method of the Chapter.

NAture (which in all her works, hath the End, and Means conducing to that End, alwayes closely connected in one idea) having ordained the perpetual generation of this vital Nectar, the Blood, in Animals, for the Uses, in the precedent Chapter recited: that she might not be deficient in the means requisite to fulfill those Uses, hath also ordained, that the blood should be carried from the Fountain to all the parts, in living streams, by a certain admirable *Motion*, necessary to its distribution through the whole body. Now, that we may fully understand the nature of this Motion, we are to consider (1) the *Manner*; (2) the *Conditions*; (3) the *Causes* of it.

2. That the Motion of the blood is Circular;

Concerning the FIRST; we observe, that the blood is continually carried, or rather driven from its fountain, the Heart, in the centre of the body, by the Arteries, to the circumference; and back again from the circumference, to the centre, by the veins, irrigating, cherishing, and vivifying all the parts, as it passeth along: and that therefore, this Motion was, by the

the glorious Inventer of it, *Dr. Harvey*, called the *Circulation* of the blood; *quòd,*

Ejus enim semper redeat labor actus in orbem.

For, in the first place, the blood is effused out of the vena Cava, into the right ventricle of the Heart; as may be evidently seen in living Animals dissected, especially in Coneys. For, if the trunck of the vena Cava be bound with a ligature, both above and below the heart; you may perceive all the blood contained in the space betwixt the ligatures, to be speedily discharged into the right ventricle of the heart, to which the vena Cava is conjoyned.

3. From the Vena Cava, into the right Ventricle of the heart.

From the right ventricle of the heart, it is (the heart contracting it self) expelled into the vena arteriosa, and so into the Lungs; but not through the septum transversum, or middle partition of the heart, as some have imagined, conceiving the same to have some certain obscure passages from the right into the left ventricle; only because they could, without much violence, thrust a style, or probe through it: when, indeed, those passages are not made by Nature, but by the point of the probe; the flesh of the heart being so tender, as that it is easily penetrated, by any hard and pointed instrument though but gently intruded.

4. From the right Ventricle, by the Vena arteriosa, into the Lungs:

Passing through the vena arteriosa into the very substance of the Lungs; the blood is immediately returned into the venosa arteria, and through that into the Left ventricle of the Heart.

5. From the Lungs, through the Arteria Venosa, into the left Ventricle.

Heart. This is demonstrable thus. Having made a ligature upon the great branch of the Arteria venosa; neer the pericardium, in the lungs of an Animal yet living; you may observe that branch to be soon filled and much distended with bloud, in that part, which is toward the lungs, and that emptied and flaccid, that is next the heart: and upon remove of the ligature, the bloud will flow amain from the lungs to the left ventricle. Now, there being no other way, by which this bloud can flow to the left ventricle, but from the lungs: it must of necessity descend thence, by the Arteria venosa.

6. From the left ventricle, into the great Artery, and thence into the smaller Arteries.

The left ventricle having thus taken in a quantity of bloud, answerable to its capacity; the heart instantly contracting it self, expelleth the same (at least, good part thereof) into the Great Artery (arising from the left ventricle) thence into the lesser arteries, and so into the substance of the flesh; from whence the bloud is intruded into the capillary veins, by them into the greater veins, from them into the vena Cava, and at length into the right ventricle of the heart, there to begin the same circular progress again.

7. From the smallest Arteries, through the substance of the flesh, into the smallest veins.

We say, from the capillary arteries into *the substance of the Flesh*. For, as to those, who will have the bloud to pass out of the small arteries, into the small veins, *per Anastomoses*, by certain inosculations, or open passages from those into these: we challenge them to demonstrate to the sense, any such way of entercourse

or

or communication betwixt arteries and veins, in the whole habit of the body; and *Dr. Harvey* did the same before us, when He said, *De Anastomosi venarum & arteriarum, ubi sit, & quomodo sit, & qua de caussa, neminem hactenus rectè quicquam dixisse, suspicari licet.* And why may not the blood be as wel conceived, to permeate through the pores of the flesh, as water through the pores of the earth, the sweat through the skin, the serum through the parenchyma of the Kidneys, or as the same blood through the thick substance of the Liver.

de mot. cord. & sang. cap. 9.

8. How the New-made blood is circulated with the old.

Nor is only that bloud brought back to the heart, by the vena Cava, which passed through it before; but the stream is augmented by the accesse of fresh Chyle also, imported into the subclavian branches of the same vena Cava, and thence into the right ventricle of the heart. For, this is not only easie to be done, in respect of the vicinity of the ascendent and descendent trunck of the vena cava, to the right ventricle: but also necessary, there being no other way for the new supply of bloud to passe; and that it is done, this experiment doth testifie. The vena cava being bound both above and below the heart; all the bloud contained betwixt the two ligatures, will in a very short space be discharged into the right ventricle.

9. That more blood passeth through the heart, in an hour, than can be supplied from the chyle, in several dayes.

Again, the Heart seems to immit more bloud into the Great Artery, in the space of one hour, than the proportion of Chyle can amount to, in several dayes. For, in most men, the Heart makes more than 3000. pulses, in an hour;

hour; and at every systole it expells some blood out of its left ventricle into the Aorta; as may be sensibly demonstrated by this, that upon a ligation of the Aorta, neer the heart, and an incision made betwixt the ligature and the heart, you may observe some quantity of blood (more or lesse) to be squirted forth by the incision, at every systole; unlesse the heart be grown weak and languid; and yet even in that case, some quantity of blood will issue forth at the hole, once in 3 or 4 pulses. Nay, when the cone or point of the heart is cut off, and the heart held upright; though the ventricles be not then full, yet will some blood be squeezed out of them, every time the heart contracts it self, and that to the distance of 3 or 4 feet, as *Dr. Harvey* observeth.

a *cap. de mot. cord. & sanguin.*

10. The Necessity of the Circulation inferred from three considerations, viz.

As for the *Quantity* of blood admitted into the ventricles of the heart, when it is dilated, and expelled into the Great Artery, when it is again contracted; it cannot be precisely determined. For, if in the same individual person, the motion of the heart, being sometimes more strong and swift, and sometimes more weak and slow, doth make the Circulation of the blood more swift, or more slow proportionately: certainly in the species, it must be impossible to commensurate the quantity of blood passing through the heart, at every pulse; since there is great variety among men, in respect of their different temperaments, ages, sexes, diet, exercises, passions, and the like, all which vary the pulse, and consequently the motion of the blood.

blood. However, that some satisfaction may be given to enquirers herein, we are to consider Three things, *viz.* (1) *How much blood may be contained in the heart of a Man, in its Diastole;* (2) *How much may be expelled out of it, in its Systole;* (3) *and How many Pulses,* or Diastole's and Systoles, *the heart doth commonly, in healthy, and temperate men, make in an hour.*

Concerning the *First*; there are different observations. *Harvey* saith, that in a mans heart dilated, he found more than two ounces of bloud. *Plempius* affirms, that he found almost two ounces. *Riolan* will allow scarce half an ounce, in the left ventricle; but somewhat more in the right. And *Hogeland* comes much lower, admitting only one dragme. But, all men generally grant, that the whole masse of blood contained in the body, doth seldome exceed 24 pounds, or pints, and as seldome come short of 15.

the quantity of blood contained in the heart, in its Diastole;

Concerning, the *Second*; we say, that in every systole is expelled, either the fourth or fifth or sixth, or at least the eighth part of the bloud received into the heart, at the precedent Diastole. *Harvey* supposeth at least one dragme, and proves that his supposition from the suddain effusion of all the mass of blood, if but the least artery be cut; and because all the blood may be transmitted through the heart, in the space of half an hour, He thereupon concludes for certain, that much blood is expelled into the great Artery, at every systole. *Conringius* also makes the same compute. *Walæus* and

the quantity expelled out of it, in its Systole.

Sleyelius

Sleyelius admit half an ounce: but compute only from one ſcruple. *Hogeland* acquieſceth in one dragme. And *Thom. Bartholinus* brings it down to only half a ſcruple. But they all agree, that in the contraction of the heart, the ſides of the ventricles are not drawn ſo cloſe together, as to expell all the bloud contained in them.

The Number of Pulſes, in the ſpace of an hour.

Concerning the *Third*, we remember, that *Primroſe* reckons 700. pulſes in an hour; *Riolan* 2000; *Waleus* and *Regius* 3000. *Cardan* 4000; *Plempius* 4450; *Sleyelius* 4876; *Bartholinus* 4400, or thereabouts; and *Harvey* about 2000; each one numbering the pulſes in his own wriſt. average 3178 ℔

Now, from theſe three things premiſed we may collect how much bloud may be expelled out of the left ventricle of the heart, into the Aorta, in the ſpace of one hour, according to the ſeveral numerations of pulſes *viz.*

from	℈j	3000	times repeated there arise	℔ 10	℥ 5			Of blood paſſing thorough the heart into the arteries, in one houre.
	℈j	4000		℔ 13	℥ 10	ʒ 5	℈j	
	℈j	4450		℔ 15	ʒ 3	℈j		
	℈ß	4400		℔ 7	℥ 7	ʒ 5	℈j	
	ʒj	2000		℔ 20	℥ 10			
	ʒij	2000		℔ 41	℥ 8			
	ʒß	2000		℔ 83	℥ 4			
	℥j	2000		℔ 166	℥ 8			

Again, ſetting it down for a ground, that the quantity of blood contained in the whole body, doth amount only to ℔ 15. (for that is according to the moſt modeſt accompt) and allowing

lowing some part thereof to be consumed by the Lamp of life, and as much to be supplied out of the Chyle: we may inferre these 4 necessary Conclusions.

(1) That more blood is transmitted through the heart, once in every hour, than can be supplied out of the Chyle, in many hours.

(2) That all the blood in the body is transmitted through the heart, once in a quarter, or half, or a whole hour, or in two hours at most.

(3) That so much is not required to the conservation of the vital Flame, and the confection of vital spirits.

(4) That, since the vessells are not broken, that the blood cannot return back out of the heart, nor be any wayes dissipated: it is absolutely necessary, that the blood must return to the heart again by the veins, or be Circulated perpetually, as the immortall *Dr. Harvey* hath demonstrated.

11. That the Circulation is *Universal*, in all the Arteries and veins of the whole body.

Nor is this Circulation of the blood only Particular to some Arteries and Veins (as some have inconsiderately imagined) but *Universal*, or common to them all, throughout the whole body. For though it be, indeed, more demonstrable to the sense in the Limbs, where the vessells being ample and conspicuous, admit of ligatures more conveniently, than those in the Inwards: yet doth observation teach us, that the motion of the blood is the very same in the very *Entralls* also. In particular (that we may deduce it through the most conspicuous Arte-

ries and veins of other interior parts, besides those already mentioned) the blood is carried, in the

- *Abdomen*, to the
  - *Testicles*, by the spermatick Arteries: from them, by the spermatick veins, into the left Emulgent and vena Cava.
  - *Intestines*, by the Mesenterick Arteries: from them, by the Mesenterick veins, into the *Ramus* Mesentericus, and thence into the vena Portæ.
  - *Spleen*, by the left Celiacal Artery: from it, by the Ramus splenicus, into the vena Portæ, and thence directly into the Liver.
  - *Stomack and Omentum*, by other branches of the Celiacal Artery: from them, by the Gastrick and Epiploical veins, into the Ramus splenicus; thence into the vena Portæ, and so to the Liver.
  - *Kidneys*, by the Emulgent Arteries: from them, by the Emulgent veins, into the vena cava.
- *Thorax*, to the
  - Outside of the Heart, by the Coronary Artery: back again, by the Coronary vein, into the vena Cava.
  - Pleura, by the Intercostal Arteries: from it, by the veins thereof, into the vena Azygos, and thence into the vena Cava.

Head,

Head to the *Membranes of the Braine*, by the Carotides and Neck-Arteries (which tend to the four Cells of the brain, but are not therein terminated, as some Anatomists have thought:) from them, by the jugular veins, into the ascendent trunck of the *VENA CAVA*.

All which is discoverable to the sense, by binding those vessels, in Animals cut up alive. For, the swelling, caused in either vein or Arterie, by the flux of bloud there arrested, will alwayes appear on that side the ligature, from whence the blood flowes.

Here we are to advertise, that in the *Fœtus*, or Infant-unborn, the manner of the Circulation of the bloud, through the vessels of the Heart, is different from that we have described. For the blood is not carried from the Mothers womb, into the Umbilical Arteries; but from the *Placenta Uterina* (in which those Arteries are terminated) into the Umbilical vein: which conducteth it along to the Liver of the *Fœtus*, from whence it is transmitted by the Vena Cava into the right Ventricle of the heart. Being brought thither, it is transferred into the Vena Arteriosa: but, because the Lungs are not yet moved, as after the birth, in respiration; and so their vessels are not dilated and contracted alternately, and consequently they can neither receive the blood

12. But, after a peculiar manner in an Infant unborn.

out of the Vena Arteriosa, nor impell it into the Arteria Venosa: therefore hath the providence of Nature contrived and framed Two peculiar passages, the one a conduit or pipe, conveying the blood from the Vena Arteriosa, into the Great Arterie; the other a certain foramen, hole, or inlett, by which the bloud passeth from the Vena Cava into the Arteria Venosa, thence into the left Ear of the heart, and so down into the left Ventricle. From thence (as well as that from the Vena Arteriosa) it is infused into the Great Arterie. So that in an unborn Infant, Nature useth the two Ventricles of the heart, as if they were but one: and this, lest the infant should have his Blood too hot and adust, while he wants the ventilation of the air, and expulsion of fuliginous exhalations, through the Lungs. From the Great Arterie, the bloud is sent into the Umbilical Arteries, which return it to the *Placenta Uterina*; where permeating the substance thereof, it is again infused into the small branches or (rather) roots of the Umbilical vein, by them into the trunk, and at length into the Liver, Vena Cava, and Heart, as before.

12. This Motion of the blood, is

Having thus explained, by what wayes the blood is moved in a round; it follows, that we consider the *CONDITIONS* of that its motion. Concerning which, we observe that the Circulation of the blood is,

Continual;

(1) *Continuall.* For, since the Heart is continually in motion, and takes in blood, in its Diastole

Diastole, and dischargeth the same again, in its Systole, never intermitting that its proper action, but in great swooning fits, or in the very article of death: it is necessary, that the motion of the bloud be likewise continuall.

(2) *Vehement*; as may be inferred from the hardness and distension of an arterie, or vein bound with a ligature. For, nothing can be distended to great hardness, by a thin and liquid matter, especially upward, unless that matter be with vehemence impelled into, and retained in it. But, this vehemence of the motion is greatest neer the heart, and is afterward diminished by degrees, according to the severall degrees of distance from the heart; so that the extream arteries have but little pulse, unless it happens, that the impellent force of the heart be encreased, as in Fevers, Inflammations, Violent exercise, some passions, *&c.* Which is also the reason, why the veins have no pulse, the impulse of the blood being less in them, than in the smallest arteries. 14. vehement;

(3) *Swift.* For, an artery or vein being compressed by ligature, will swell up and be distended, as it were in a moment; and the blood may be observed to flow in its course very swiftly, so soon as the ligature is removed. But how swiftly, is not easily determined; there being so great variety of Causes, Natural, Nonnaturall, and Preternatural, that accelerate or retard the flux of the blood: only thus may be inferred from the precedent compute of the 15. swift;

number

number of Pulses, and the quantity of blood expelled out of the left ventricle of the heart, in every systole, That the whole mass of blood doth pass through the heart once in an hour or two, at most. Yet is not the current of blood neer so swift in its channels, while they are whole, as when one of them (vein or artery) is cut: because in that case, the blood streams forth into the free and easily-yielding aer, without any resistance; but being confined in its vessels, it is forced to distend them, and drive on the foregoing current.

16. Of equall velocity in the Arteries and veins.

(4) *As swift in the Veines, as in the Arteries.* For, though the impulse be more vehement in the atteries, as being continued to the heart, than in the veins; and therefore it might seem reasonable, at first consideration, that the motion should be proportionately more swift in the arteries: yet, considering, that the Arteries are still smaller and smaller toward their extremities, & that the flux of the blood must needs be more and more retarded, as it approacheth those extremities; and on the contrary, that the veins grow wider and wider, from their extremities, to the centre of the body, and so the blood hath still larger and larger spaces to run through, in its return to the heart; we may safely conclude (conjecturally) that the velocity of the motion is as great in the veins, as in the arteries. This is also confirmed by sense; for, the Vena Cava, in all that tract from the Liver, to the subclavian division, may be observed to beat, as often as the

Great

Great Artery; and so must import blood into the right Ventricle, as fast as the *Aorta* doth export it from the left. Which doubtless is the reason, why the Vena Cava hath fleshy Fibres upon it, when it approacheth the heart. Nevertheless, we conceive the motion to be swifter in the Arteries, when the heart contracting it self, doth impell the blood into and through them: than when, dilating it self again, it doth intermit that its impulse. Which is true likewise of the blood in the veins, as may be sometimes observed in *Phlebotomy*, when the ligature is not so streight, as to cause much distension of the vein, in which the incision is made: for, in that case, the blood wil flow forth more swiftly, every time the heart is contracted. And these are the *Conditions* of this admirable motion of the blood.

Lastly, concerning the *CAUSE* of this motion; it is necessary that the blood be moved either by it self, or by some other principle: and if it be the Author of its own motion, then that must be in respect of either an inherent motive-Faculty, or of its Ebullition, or of its Rarefaction, or of its Quantity, whereby the Ventricles of the heart are distended, and so irritated as to discharge the same, by contracting themselves. If the motion be derived from an External principle; then it must be referred either to Attraction, or to Vection, or to Pulsion. Let us, therefore, see which of all these may be the most likely cause of the Motion of the blood.

First,

17. The blood, not the cause of its owne motion, in respect of any motive *Faculty*, inherent in it.

First, That the bloud is not the cause of its own Motion, *ratione insitæ sibi Facultatis*, by reason of any inherent Faculty; may be inferred from hence, that in bloud effused out of its vessels into the body, or any other receiver, no motion at all can be observed: and it is hard to conceive, that it should be so corrupted in a moment, as wholly to lose a faculty essential to it. *Dr. Harvey*, we confess, affirmeth, that he observed a certain obscure motion of the blood, in the right ear of the Heart (where He supposeth the motion of the Heart first to begin, and last to end) after the Ear had ceased to move; but we refer that to the Mication of the blood from the Vital Spirits not yet wholly extinguished.

18. Nor, in respect of its *Ebullition*.

Secondly, That it is not the Author of its own motion, *ratione Ebullitionis* (which *Arist.* calls ὄγκωσις) is manifest from these subsequent reasons. (1) No Ebullition can be constantly equall, or of the same tenour: but the Pulse of the heart, and so the motion of the bloud, is, in temperate and healthy men, for the most part equall. (2) As the Ebullition is greater, so would the pulse; but in burning Fevers, the Ebullition is extream great, by reason of the great intension of the heat; and yet the pulse is frequently small, and weak; as also in the beginning of putrid Fevers, as *Galen* long since remarked. (3) The blood suffers no ebullition, as it passeth through the heart. For, if in the dissection of a living Animal, you make an incision either into the left Ventricle of the heart,

heart, or into the Great Artery neer it ; you shall perceive the blood flowing out at the hole, to be pure and such as before it came into the heart, not frothy, boyling, or rarefied; and to continue such as at its first efflux: yea, more, if you receive the blood issuing from an incision of the *Vena Cava*, in one sawcer, and that issuing from the left Ventricle, in another; you shall not be able to discern any difference betwixt the one and the other, either soon, or a good while after. An invincible argument against the Ebullition of the blood, first imagined by *Aristotle*, and since defended by many great men, his sectators. (4) The plunging an arme or legg into cold water, would suppress the Ebullition, and consequently the motion of the blood. For, if you apply a close ligature to a mans arme, and then immerge the same into cold water, or Snow; upon solution of the ligature, he shall find the blood returning to his heart, with so great a sense of cold, as very much to offend him. Which cold arising to the bloud, from its being long detained in the extremities of the arme bound ; *Dr. Harvey* will have to be the cause of swooning immediately after blood-letting, in many men; the heart receiving injury from that acquired cold.

Thirdly, Not *ratione Rarefactionis* ; because (1) in living dissections, where the heart yet continueth its motion, no man ever hath, or can observe any such thing as rarefied blood to flow from either the left ventricle, or the 19. Nor of its *Rarefaction.*

Great Artery, if cut; but pure and such as is from the Ears let down into the ventrices. (2) The Heart it self, when cut in pieces, or wounded, may be observed to beat; yet not from any rarefaction of the blood, for then it hath no blood in either of its Ventricles, or Ears. (3) It hath been observed in Doggs, that after the point of the heart hath been cut off, and the remainder turn'd upside down, though the ventricles could not be halfe full, the blood hath yet been squirted forth at the top, even to the distance of three or four feet; which were impossible, in case the rarefaction of the blood were the cause of its motion. (4) The musculous flesh of the heart, is more firme and strong, than to be subject to inflation and detumescence, meerly from the rarefaction of the blood. It must be a more forceible Agent, that moves that great and weighty machine of the heart. (5) If the blood were so much rarefied in the Ventricles, then certainly ought the orifices of the Vena Arteriosa, and Aorta, to have been much larger, because the blood would have required more room for its egress, than for its ingress. (6) The motion of the heart, and of its valves would be confused; for the Diastole of this, and opening of them, would happen at the same time, and consequently the valves would become useless; both which are repugnant to experience. Besides, the opening and shutting of the valves would be co-incident with the Systole of the Great Artery. (7) That the blood

blood should be rarefied in the heart, and in a moment again refrigerated in the arteries; is contrary both to sense and reason: and if the rarefaction should so soon cease; why is it at all?

21. But of its *Quantity* distending the Ventricles of the heart.

It remains, therefore, that if the blood be the efficient of its own motion, it must be so only *ratione Quantitatis*, by reason of its quantity filling and distending the Ventricles of the heart, and irritating them to discharge it, by contracting or shutting themselves. For, the heart being as it were burdened with the blood distending its cavities, doth contract its Fibers and so its Ventricles, to vindicate it self from that oppression; no otherwise than the stomach, guts, bladder, womb, *&c.* which being extended by meat, chyle, wind, urine, and the infant, drive themselves together, by the help of their Fibers, and so exclude that was burdensome to them. And thus is it probable, that the Heart is continually moved by the blood, like a Mill perpetually agitated by a stream of water; which stream being cut off, the motion instantly ceaseth. This may be credited upon the force of this one experiment; if the *Vena Cava* be intercepted by a ligature, so soon as the heart hath disburdened it self of what blood it hath received from thence, it instantly remitteth its motion; and upon letting in the stream again, by removing the ligature, it as suddenly recovers it. Than which there cannot be a more convincing argument, that the quantity of the blood flow-

ing into the ventricles, is a cause of the motion of the heart, and so of its own motion.

21. Th blood not moved by *Attraction*;

We say, *A Cause*; not the only cause: for we shall soon find another efficient as necessary and immediate, to the motion, as the blood in the respect mentioned.

That nothing doth *Attract* the blood either to or from the heart, is evident from hence; that in Nature there is no such thing, as the motion of a body by attraction; as hath been by solid and irrefutable arguments proved by that heroical wit, and most accomplish't Scholar, *Dr. Ent*; and also by our selves, in the beginning of our discourse of *Occult Qualities*, whither (for expedition sake) we refert the unsatisfied.

Apolog pro circulat sang. adverf. Parisan. a pag.27.ad 49.

22. Nor by *Vection*;

Nor is it moved, *per modum Vectionis*, by way of Carriage. For, nothing can be imagined to carry along the blood in its course, but the spirits; and those would, in respect of their Levity, carry it only upward: but we see that the blood is moved also downward, and *ad latera*.

23. But by *Impulsion* of the heart, endowed with a Pulsifick Faculty.

It remains, therefore, that the blood is moved in round, *per modum Pulsionis*, by *impulsion*, or *protrusion*: and the Impellent can be no other, but the *Heart* contracting it self, and so expelling the blood contained in its ventricles into the Great Artery, from whence it is urged, or pressed forwards into the smaller arteries, by the succeeding current. We conceive, therefore, that the Heart is endowed with a certain Motive-virtue inhærent and essentiall, called the *Pulsifick Faculty*, which is conjoyned,

conjoyned, as a concomitant cause, with the blood it self, in giving it a due motion: whether it be, that this Faculty doth regulate the influx and efflux of the blood, which would otherwise be irregular; or that of it self it produceth the motion, which cannot be afterward continued, in case the flux of the blood be once interrupted. That this Faculty is necessary, may be inferred from these *Reasons*.

(1) As the Pulse, so the influx of the bloud would be alwayes unequall, unless it were regulated by a Faculty. (2) When the bloud is moved vehemently in Fevers, by the intense heat agitating and urging it; and in men at the point of death, *propter extremos naturæ conatus*, by reason of Natures agony and last efforts: yet is the pulse more weak and low, than at other times, because the Pulsifick Faculty is either much oppreſt, or much weakned. On the other side, though the Faculty continue strong, yet is the influx of the bloud much diminished, after large hæmorrhages, or upon great obstructions of the capillary arteries and veins, in the habit of the body. Which consideration seems to us sufficient to import the necessity of conjoyning a Pulsifick Faculty, with the quantity of the blood distending and so molesting the Heart, as a *double proxime cause* of the bloods motion.

(3) Though the heart be cut in pieces, yet will each piece have a kind of weak pulsation, as long as it continues warme; which in all probability is to be ascribed to the Faculty implanted

planted in all its Fibres, and not yet utterly destroyed.

(4) It would be derogatory to the majesty of that Prince of all the parts, the Heart, to be moved by the violent impulse of an external principle, and it self conduce nothing thereunto.

Notwithstanding these reasons alleaged, we dare not set up our rest in this doctrine of the Ancients, concerning a Pulsifick Faculty implanted in the heart: only we have recited it, as the most probable Conjecture of all others, touching this abstruse Argument, the proxime Cause of the Motion of the blood. Nor shall we adhere to it longer, than untill we shall be so happy as to meet with a more satisfactory solution of that admirable Phænomenon. In the mean time, Modesty commands us to declare, that we find this Knot to be too hard and intricate for the teeth of our weak understanding. And well may we make this acknowledgment, when the subtle *Fracastorius*, after a long scrutiny into the same subject, was at length forced to desist, with *Motum cordis soli Deo cognitum esse opinor*; and that even *Harvey* himself professeth, that He found it *rem arduam & difficultatibus plenam.* We remember the modest sayings of two great Men, upon the like difficulties; the one of *Galen*, *Quo pacto hæc fiant, si scrutaberis; convinceris te non intelligere neque tuam imbecillitatem, neque Opificis tui potentiam*: the other of *Scaliger*, *Quandam humanæ sapientiæ partem esse, quædam æquo animo nescire*

lib. 15. de usu part. cap. 1. exercit. 307. num. 29.

velle;

velle; & veram sapientiam, nolle nimium sapere. And we think, we need say no more, in excuse of this our professed ignorance.

Besides this Two-fold Proxime Cause, there is also another *Remote* one, *viz.* the *Peculiar Conformation, or Fabrique, of the Heart and its vessells.* And among all the parts in this curiously framed Machine of the heart, those which are most official or instrumental to the motion, are the *Fibers* and *fleshy columnes*; which serve not so much to the strength of the heart, as to the motion of it. For, in the Systole, all the Fibers, both small and great, as well those in the inside of the ventricles, as those in the Septum, or partition-wall betwixt them (like an artificial network made in the forme of a purse) being contracted, or drawn together; the blood contained in the ventricles, must necessarily be expelled or pressed out of them.

24. The *Fabrique of the heart*, a *remote* cause of the motion of the blood.

The *Motion of the heart*, which is called the *Pulse*, as being continual, and made partly by the influx of the bloud, partly by the Pulsifick Faculty residing in the heart it self; doth consist of 3 things, the *Systole*, the *Diastole*, and the *Perisystole*: all which are to be explained by their proper Causes, according as ocular Inspection, and Reason doth dictate them to the understanding.

25. The *Motion* of the Heart described; as consisting of two *contrary motions*, and a *Respite* betwixt them.

(1) The *Systole*, being the proper and natural motion of the heart, is the Contraction or drawing together of the heart to a narrower compass, that so the blood contained in the right ventricle may be expelled through the

vena

vena arteriosa into the Lungs; and that contained in the left, may be expelled into the Great Artery, and so into all parts of the body.

(2) The *Diastole*, being a motion only Accidentary to the heart, is a Dilatation, or opening of the heart, that the blood may flow into the right ventricle, out of the vena Cava; and into the left, out of the Arteria Venosa.

(3) The *Perisystole*, is a certain quiet or short respite betwixt the Contraction and Dilatation of the heart, during the small time, that the blood is entering into, or issuing out of the ventricles. In healthy men, this pause is so short, as not to be distinguished from either of the two contrary motions: but sufficiently manifest in men at the point of death. It is also *double*, there being one respite betwixt the Systole and Diastole; and another betwixt the Diastole and Systole. And this is the natural state of the Heart.

26. And the *Figure* of it in each.

As to the *Figure*, or *Forme* of the heart in those contrary motions; from the dissection of Animals alive, from the commodity of its motion and quiet, and from the position of its Fibers and other parts, we have learned it to be thus.

In the *Systole*, it may be observed that (1) the point of the heart is drawn upward toward the Basis of it, in order to the expulsion of the blood; the length of it being diminished, and bredth proportionately encreased: because the basis is immoveable, in respect of the cone, which

which is fastned neither to, nor by any vessells. (2) The *inner* walls, or sides toward the ribbs, are brought neerer each to other; because they are constringed and made narrower, as may be perceived by putting a finger into either of the ventricles, at the time of their contraction: but the *outward*, becoming tumid, seem to be enlarged in latitude, from the contraction of all parts inflated in the tension or stretching. (3) The fore part of the heart is lifted up towards the sternum, and chiefly neer the base; for, where the pulse is felt, there doth the heart strike the breast with its base, that part being lifted up, and brought neer to the sternon: and at the same time (not in the Diastole) is the heart vigorated, and the arteries dilated and filled; and the pulses are felt both in the breast and wrist, the Diastole of the Arteries being coincident with the Systole of the heart. But the Pulse is more plainly felt in the left side, because there is the origine and orifice of the Aorta. (4) The whole heart becomes tense and hard, and contracted to a smaller bulk; as is manifest both to the sight, and to the touch. (5) The heart appears white, especially in imperfect Animals, such as Serpents, Frogs, Eeles, &c. by reason of the expulsion of the blood in the Systole.

In the *Perisystole*, when the heart is soft, lux, and in its proper state, (1) the cone recedeth from the base; and in some Animals, the base also recedeth from the cone: (2) The lateral parts, both the interior and exterior, are

tended toward the ribbs : (3) The anterior face of the heart sinks down, and the posterior is depressed, especially neer the orifice of the great Artery.

In the *Diastole*, which beginns in the middle of the Dilatation, and ends in the middle of the Contraction. (1) the upper side is lifted up and distended by the blood falling into the ventricles out of the Vena cava, and Arteria venosa; the swelling sensibly beginning at the base, and progressing to the cone. But the base doth not then strike the breast, because the Arteries at that instant are contracted; and the heart ceaseth from expulsion of the blood. (2) The heart is flaccid and soft, because it is then only passive, in receiving the blood. (3) The sides become extense, and the cavities enlarged, and therefore if you put your finger into the heart, during the Diastole, you shall perceive no constriction, as in the Systole. (4) The heart appears red, because of the tenuity of its walls, and their repletion with blood. (5) The Cone receding from the base, makes the heart longer, that it may be more capable of blood. And thus doth the heart vary its Figure, in each of these three positions.

OF

OF THE DEPURATION OF THE BLOOD.

Exercitation the Seventh.

Of the Depuration of the BLOOD.

FRom the Circulation of the blood, we (as Nature) advance to the *DEPURATION* or Defecation of it, from its unprofitable or excrementitious parts. And here we are to consider (1) the *Generation*, (2) The severall *sorts* of Excrements generated in and to be separated from the blood, (3) The *parts* in which, and (4) The *Manner how* they are separated.

Concerning the *FIRST*, we observe, that the blood being a heterogeneous liquor, consisting of various Elements or material principles (as the Element of which it is generate) and so not capable to be wholly changed into either the fewel of the Vital Heat; or Vital Spirits: when those parts of it, which had their Spirits less closely and firmely united to their grosser Elements, or (which is the same thing) which were most prone to volatility; are

I. The Genealogy of the Excrements.

are consumed and dispersed; it cannot be, but that the remains or reliques thereof must thenceforth become not only useless, but also incommodious to Nature, and therefore as soon as may be, to be rejected. For the sweet and inflammable Spirits of the blood being exhausted; to what use can the remaining mass serve? It can be no longer the subject or residence of the Vitall Heat, for the conservation whereof the blood is principally made: nay, if retained in the body, it would rather damnifie and destroy the same noble principle, the Vital Heat. For, the *Sulphur* contained in the blood, doth by reason of the continuall mication and indeavour of the Spirits to fly away and disperse themselves, and of the decocting activity of the Vitall Heat exercised upon it, become adust, and contract a manifest bitterness and acrimony; and the *Caput mortuum*, or Terrene and grosser part, conjoyned with the Fixative Salt, is apt to coagulate and to be petrified; and the *Phlegma*, or insipid and viscid part is apt to obstruct the capillary arteries and veins, and so impede the Circulation; and lastly, the *Aqueous* part, or potulent matter, as being apt to render the bloud too dilute and serous, is wholly unprofitable. These parts, therefore, being no longer usefull ingredients of the bloud, degenerate into Excrements; and ought to be sequestred from it.

This Generation of the Excrements of the bloud, may be appositely adumbrated by the Exam-

Example of Wine distilled. For, as Wine is a Liquor consisting *ex Elementis primiceriis*, of Various choyce ingredients, or dissimilar parts: so is the blood. As the Spirits or more fugitive parts of Wine, are easily separable from the more fixed, *viz.* the Phlegme, Tartar, crass Sulphur, *&c.* by heat: so are the Spirits of the blood easily separated from the more fixed parts of it, *viz.* the Phlegme, Salt Tartar, crass Sulphur adust, the Aqueous or potulent matter, by the activity of the Vital Heat. As the Spirits of Wine are, by repeated destillations, advanced to that height of Volatility or subtility, as that some of them flye away and are dispersed into air, in every rectification: so likewise are the Spirits of the blood, by repeated Circulations through the heart, brought to that degree of subtility and volatility, as that they cannot be longer contained or imprisoned in the body of an Animal, but penetrating through the pores, are exhaled by way of dry sweat, or insensible transpiration. And as the residue of the Wine, after the Spirits are gone, remains a dead mass, or vappa, consisting only of a Phlegme, Tartar, and crass Sulphur (which by long heat acquireth a bitterness and acrimony:) so doth the residue of the blood, after its Spirits are exhausted and dispersed. For, (as we said afore) the caseous and grumous parts of the blood, being brought to the state of Fusion, by the Vital Heat, make that excrement called the Phlegma: the Saline and earthly parts consociated, make the Tar-

2. Exemplified in the destillation of wine.

tar,

tar, which being dissolved and kept fluid by the potulent matter (to which it is easily mixed) make the Urine: and the crass sulphur, torrified by the Vital heat, and inseparably floating in the serum, makes the Bile, or Cholerick excrement. And this Diversity of parts in the blood is evident even to the sense, in blood let forth of either vein or artery into a vessell. For, there the caseous or grumous parts (which being most elaborate, and brought to a certain degree of Fusion, have thereby acquired a viscidity) swim on the top, in the forme of a whitish filme or membrane; while other parts of the same kind, having not attained to the like degree of Fusion and viscidity, sinck to the bottome; and the serous or watery (impregnated with the Salt, and somewhat of the crass Sulphur adust) flow round about the rest.

3. The Various sorts of those Excrements: and their Definitions.

Concerning the SECOND, *viz. the various sorts, or Kinds of Excrements* to be separated from the blood, in order to its purification; though what we have now said, concerning their Original, may seem to intimate their several Families and specifical Differences: yet will it not be superfluous to observe further, that all of them, being Liquid, fall under two General Kinds. The *First* comprehends the *More Thin* Excrements, which are (1) the *Urine*, impregnated with the *Tartar*, (2) the *Sweat*, (3) the *Tears*, and (4) the thin *liquor* contained in the *Lympheducts*: The *Other* includes the *Lesse Thin*, which are 1) the *Phlegme* or pituitous

tuituous Mucus: whether it be *Acid*, such as is found in the stomach and guts; or *Insipid*, such as the Rheum distilling from the brain by the palate and nose, the spittle, and salivous moysture excerned from the *Glandulæ sublinguales*; (2) the *Bile*, both that which is collected in the bladder of the Gall, and that deposed in the cavities of the Ears, called the *Ear-wax*; for these two seem to be cousin germans, and differing only in consistence.

The *Urine*, is a serous excrement, impregnated with Tartar, and tincted with a small portion of the Bile; brought by the Emulgent arteries, into the Kidneys, together with the blood; there separated from the blood, by a kind of percolation, thence distilling by the Ureters into the bladder, and at length avoided by the urinary passage.

The *Sweat*, is likewise a serious excrement, impregnated with a small quantity of Salt, expulsed out of the capillary arteries into the habit of the body, and thence excerned through the insensible pores of the skin.

Tears also are a serous and brackish excrement, imported by the arteries into the *Carunculæ Lachrymales*; or smal Glandules, placed in the interior corners of the Eyes; there separated, by a kind of percolation, from the blood; and thence expressed, for the most part voluntarily, in griefe, and sometimes in suddain and profuse joy; and sometimes involuntarily, in pain, fevers, *&c.*

The *limpid Liquor found in the Lympheducts*

(at

(at least a good part thereof) is a mild and insipid exhalation of the blood in the arteries, sweating through the coats of the smaller arteries, collected by degrees in the Lymphe-ducts, and by them again infused into the blood, as well to prevent the coagulation, as to promote the mication thereof; and after various Circulations, avoided by evaporation through the skin.

Among the Less Thin Excrements,

The *Phlegmatick mucus* found in the stomach, is a thick viscid excrementitious juice, endowed with some Acidity, brought into the coats of the stomach, by those branches of the Celiacal artery, which are therein terminated there secerned from the blood, and by transudation immitted into the cavity of the stomach; to the end, that it may serve to excite the Appetite, and in place of a Ferment, promote the dissolution and concoction of the meat.

The *Pituitous Mucus* found in the Guts, is an insipid excrement spewed out of the Mesenterick arteries, into the substance of the guts, transmitted by insensible passages into the hollow of them; serving to defend them from the injuries of the Chyle and excrements of the belly passing through them, and at length to be excluded together with those excrements, by stool.

That *distilling from the Brain*, is a pituitous excrement, severed from the blood brought thither by the Arteries, and excerned either by

by the Palate, or nostrills. Such also are the sputum, which falls down from the pituitary Glandules situate about the basis of the brain: and the saliva, which is generated of humours imported into the Almonds of the Ears, the *Glandulæ sublinguales*, and other spongy parts in the jawes and mouth, and therein separated; for the moystning of the mouth, and softning of the solid meat, in mastication.

The *Bile*, or *yellow Choler* found in the bladder of the Gall, is a bitter excrement, generated in the blood, of the crass sulphur thereof (dissolved by the serum) made adust by the vital heat; separated in the Liver, and thence conveyd by convenient vessells (which we shall particularly mention anon) into the Intestines, to be excluded with the excrements of the belly.

Lastly, the *Ear-wax* is a bilious excrement, thick, yellow, and bitter, in small quantity effused out of the capillary arteries neer the Ears, and collected in the *meatus auditorius*.

4. The Reason, why each particular Excrement is determinately imported into the part particularly comparated for its separation; is

The Material principles, Generation, Differences, and particular Essences of these Excrements, being thus explained; it followes that we now discuss the Manner of their separation from the blood, in the parts specified, framed by Nature to that end. Which that we may do with the more satisfaction and perspicuity; it is requisite, that we premise some short disquisition, as well concerning the Reason, why such or such Excrements (all being promiscuously blended together, or flowing

 confusedly

confusedly together in the arteries with the blood) are yet carried into such or such parts, rather than into any others: as concerning the various wayes Nature hath contrived, for the separation of Humours each from other, in the body. For, these Generals being explicated, anticipate the remove of many of those difficulties and obscurities, that we shall encounter in our scrutiny into Particulars.

Concerning the *Former*, therefore, we advertise; that the Reason, why the Acid Phlegme contained in the blood, is imported rather into the Stomach, than into the guts; the Insipid Phlegme rather into the Guts, than into the stomach; the serum into the Kidneys, rather then into the Liver; and the Bile into the Liver, rather than into either the Stomach, Guts, or Kidneys: we say, the reason of this, is not that each particular Excrement is so directed, by any Intelligent Faculty, whose office is to distinguish not only the excrementitious parts of the blood from the benigne and profitable, but also the excrementitious one from another, and to dispense each to the part ordained for its separation: nor that each excrement is attracted by and to its like, as if the Phlegme preexistent in the stomach and guts did, by reason of similitude of substance, draw to it self those Phlegmatique particles of the blood, that hold the neerest analogy to its own nature; and so of the serum in the Kidneys, the Bile in the Liver, *Porus bilarius*, and bladder of the Gall, &c.

Not

Not by any *Intelligence*, or *distinguishing Faculty*; because the soul, or Mind (whose Function is only to rationate, or think) is conscious to her self of all her actions; but no mans soul is conscious of any such act, as the distinction of Excrements: And to assigne a distinct Faculty to every distinct operation in the body, is (as that wonder for Wit and Learning, *Dr. Ent*, acutely said) *Deos advocare in theatrum, ut solvant nodum fabulæ.*

Not, that it is so directed by any *Intelligence*, or distinguishing faculty.

A course frequently taken, and eagerly pursued by many Philosophers even of the highest forme; but, in truth, so manifestly erroneous, as to refute it self. For, those fruitfull imaginations, that first hatched and introduced the *Faculties Attractive, Retentive, Concoctive*, and *Expulsive*; might, if they pleased, have invented and added as many more to preside over each particular humor and Excrement in the body, and multiplied them even to infinity: the difference of those Actions (and indeed of all others done in Animals) arising really from the different constitutions and structures of the organs, wherein they are performed.

Nor by *Spontaneous Coition*, or *Attraction Similary*; because in Nature there is no Motion by Attraction, but all from Impulsion; and if there were, yet could not one excrement draw another of the same kind, because *Simile non potest agere in simile, quà simile; non magis certè, quàm in seipsum.* To which we may adde, that though many great men have laboured much to assert this opinion of Attraction *propter*

5. Nor that it is *Attracted* by the like Excrement contained in that part:

 ὁμοιώσιν,

ὁμοίωσιν, by reason of similitude or familiarity of substance: yet could none of them make it so much as intelligible; and therefore *Regius* did well to say, *Excrementorum attractio & spontanea coitio, sunt rejiciendæ, quia non sunt manifestæ vel intelligibiles, nec probatæ.*

6. But, that there is a certain peculiar *Conformity of magnitude and figure*, betwixt the minute particles of this or that Excrement, and the pores of this or that part constituted for the reception of it.

To what, then, shall we ascribe this so admirable effect? Why truly, according to the most of probability, to nothing else, but the *Correspondence of Magnitude and Figure betwixt the minute particles of this or that peculiar excrementitious humor to be separated from the blood, on one side; and the small passages leading into, and insensible pores in this or that part, peculiarly constituted for the separation thereof, on the other: together with the help of that particular Fermentation, which each humor doth suffer either near unto, or in the place of its separation*; to Nature nothing being more frequent, than to make use of a certain *Fermentation*, greater or lesser, where she intends a separation of various humors one from another.

For, since each particular Excrement doth consist of particles of a determinate Magnitude, and determinate Figure; and that each separatory organ in the body hath likewise not only a distinct manner of Conformation of its conspicuous vessells, parenchyma, and other sensible parts; but also its insensible particles, passages, and pores, of a particular magnitude and figure, different from those of all other organs, and accommodated only to that Action or Office, for which the same was made: it is

highly

highly reasonable to conceive, by way of inference, that the blood being diffused through the arteries, by the impulse of the heart, indiscriminately and equally to all parts of the body; yet each part doth admit and receive only those parts of the blood, which in respect of the magnitude and figure of their minute particles, are most correspondent or agreeable to the magnitude and figure of its slender passages and pores; and exclude the others, wherein is no such analogy or suitableness. And hence, doubtless, is it, that the serous part of the blood is determinately imported into the Kidneys; the Phlegmatique into the stomach, and guts; the Bilious into the Liver, &c. rather than into any other parts: the capillary branches of the arteries, and the insensible pores of the substance of each of those parts, being in magnitude, figure and situation respectively accommodated or adapted to the receiving and imbibing of the humor brought to it.

7. Which is also the Cause of the separation of particular Excrements, in particular parts.

And for the Separation of each of these Humours thus admitted into these or those parts; we conceive it likewise to belong to the very same Cause, as their Reception or Admission doth; *viz.* to the determinate magnitude and figure of the insensible passages and pores in the Parenchyma of this or that part. Because the separation of each Excrement is effected by a kind of Cribration, or Percolation; and in all percolations, the particles of the matter transmitted, ought both in magnitude and figure, to hold an analogy with the pores of the body,

through

through which they are transmitted. Now, that the Parenchymata of the separatory organs named, are endowed with various secret passages and pores of different magnitudes and figures; is manifest from hence, that their component particles are variously contexed, (in one more loosely, rarely and thinly, in another more closely, densly and thickly) and the vessells and Fibers running through them as variously formed, in magnitude, longitude, position, number &c. and where such variety is, it doth necessitate an equal diversity of pores, which are nothing else but the void spaces betwixt the solid particles. And, that these Excrements may be (to omit, that they are) easily transmitted through such narrow and slender passages and pores, however inconspicuous and undiscernable by the sense; cannot appear difficult, or incredible to any man, who shall but observe, how blood will issue forth of the skin, if it be pricked with the point of even the smallest needle. And thus much of the *Former part* of this *previous Disquisition.*

8. As for the *Other*; though the *Colatures*, which Nature hath instituted, for the separation of Humors in the body, be manifold and various: yet may they all be commodiously reduced to *Two Kinds*, all being in order either to *Nutrition*, or to *Excretion*.

The Differences of *Colatures*, used by Nature in the separation of Humors in the body.

Of the *First* Kind, we have an example in the Nutrition of the Fibers and Membranous parts of the body. For, it is most probable, that those parts (if not all the rest) are nourished

rished by the *Succus Nutritius*, brought to them through the Nervs; and that Aliment, being somewhat glutinous, like the white of an Egg, cannot easily penetrate into their substance, without the help of a certain thin and watery vehicle; which having once done that office of introducing the *succus nutritius* into these parts, becometh thenceforth unprofitable to them, and so is presently discharged by the *Lympheducts* into more ample spaces.

Of the *Other Kind*, there are *Three distinct sorts*. Whereof the *First* is, *when the thicker humor is retained, and the thinner rejected*: of which we have an example in the Kidneys, where the serum is transmitted into the Ureters and bladder, while the pure blood is retained, to be returned into the vena Cava, by the Emulgent veins. The same is also effected in the separation of Sweat, Tears, and spittle.

The *Second* (contrary to the first) is, *when the thinner humor is retained, and the thicker rejected*; as in the coats of the stomach and guts, where the Mucous Excrement or Phlegme is transmitted into their cavities, and the blood retained to be sent by the veins into the vena portæ: and in the brain, in which the like Mucus is separated from the blood, and deduced into the palate and nostrills.

The *Third*, *when two humors of equal consistence or thicknesse are separated one from the other*, this being retained, and that rejected. And this Colature is performed in the parenchyma of the Liver. For, the Felleous humor, and the blood,

blood, while warm, are very neer of equall thickness: and yet hath nature found out a certain way of percolation, which easily distinguisheth and separateth them each from other A thing far transcending the industry of man, who can make no Artificial Colature, by which two Liquors of equall consistence may be separated one from another.

These Considerations premised in the General, we now at length come to explicate the *Particular Manner*, how each Excrement is separated, in its peculiar place.

9. The Reason and Manner of the separation of the *serum* from the blood, in the *Kidneys*.

The blood in its Circulation, being, by the pulse of the heart, impelled into the Emulgent Arteries, flowes along into the several branches, or ramifications of them, and at length into the smaller surcles, or capillary arteries, which running out into smaller and smaller threads, till they become inconspicuous, lose themselves in various parts of the substance of the Kidneys, infusing the blood yet commixt with the serum, into the same. This Parenchyma or substance of the Kidneys, consisting of various parts diversly contexed and conformed, and having Pores of different magnitudes and figures and positions running through it, whereof some pores are more accommodate in magnitude and figure, to the minute particles of the blood, and others more correspondent to those of the *Serum*: the blood taketh its way through one sort of pores, into the capillary branches of the Emulgent veins, that lye open and ready to receive it in all

parts

parts of the parenchyma, and thence to lead it along into the Vena Cava; and the Serum taketh its course through the other sort of pores, into the Papillary Caruncles, which being pervious into the branches of the Ureters (in like manner variously dispersed up and down, so as to receive it from the Caruncles) convey the same into the truncks of the Ureters themselves, from whence it spontaneously destilleth into the Bladder, which by contracting of its self expelleth it in Urine. And this we conceive, to be the true manner of the Percolation of the Serum, made in the substance of the Kidneys.

10. Of the *Phlegmatick* Excrement, in the *stomach* and *guts*.

When the Celiacal and Mesenterick Arteries have, by those their branches, that tend to those parts, brought the blood not yet purified from the *Phlegmatique Excrement*, both Acid and Insipid, into the capillary arteries dissminated upon the coats of the Stomach and Intestines: in which there is a diversity of Pores or insensible passages, some direct, some oblique, in a word, some, in respect of their magnitude, figure and position, peculiarly accommodated to the admission of blood; some to the admission of Acid Phlegme; and others to the admission of Insipid: it comes to pass, that by reason of this Diversity of secret passages, the blood is impelled into the pores most analogous to its minute particles and through them into the capillary veins respondent to the capillary arteries, and thence into the larger veins, which soon discharge it into the Vena

portæ; while the Acid Phlegme is protruded forward into those pores, that are most conformable to its minute particles, and through them at length into the cavity of the stomach; and the Insipid likewise is transmitted through those pores, that are most Symbolical to the magnitude and figure of its minute particles, into the cavity of the Guts, there to defend them a while from the injuries of the Chyle and Excrements, and upon the accession of a new supply of the like insipid Phlegm, to be excluded together with those excrements, as we said before. And this we conceive to be the way of percolation Nature useth, for the separation of the Phlegme from the blood, in the stomach and intestines.

11. That the *Bilious* Excrement doth accompany the Phlegmatique, to the stomach and guts; and why.

Thus long doth the *Bilious* Excrement inseparately accompany the *Phlegmatique*, flowing along together with it through the branches of the *Celiacal* and *Mesenterick* arteries, into the coats of the stomach and guts; but, when it once comes there, it leaves its associate, the Phlegme, to be, after the manner expressed, transmitted into their cavities, and being throughly commixt with the blood, is propelled into the extremities of the capillary veins, answering to the extremities of the capillary arteries, that brought it thither; and from thence is carried along into *Vena portæ*, and at length into the substance of the Liver, therein to be segregated from the blood. Nor, indeed, ought this Bilious Excrement to be sooner

sooner dissociated from the Phlegmatique; or conveyed by any neerer way, or shorter cut, in direct vessels tending from the descendent trunk of the great attery, to the trunk of the *vena portæ*; and that for *Three* important *Reasons*.

First, it seems necessary that the Bilious humor should accompany the Phlegme, untill it hath brought the same into the substance of the stomach and guts; because the Phlegme, being a mucous and viscid humor, would be apt to obstruct the capillary vessels, and insensible pores of those parts, unless it were made more dilute and penetrative, by the admixture of the Bile, an humor penetrative and detergent, and so fit to prevent obstructions. This reason may receive verification from hence, that Men of a hot and cholerick constitution, and such in whom this Bilious Excrement doth abound more than in others, are seldom or never troubled with obstructions of the stomach and guts, by gross and viscid humors: whereas, on the contrary, those of colder complexions (especially Virgins *Leuco-Phlegmatique* and afflicted with the Green-sickness) in whom less of choler is generated, are commonly oppressed with oppilations of those parts, from abundance of tough and tenacious phlegme.

Secondly, the Bilious humor it self seems to require some certain degree of *preparation*, conductive to its future separation, before it can be commodiously imported into the Li-

ver. For, should it be convey'd into the Liver, directly out of the descendent trunk of the great artery; it could not be avoided, but some part of the Phlegme would also be carried along with it: because those humors, while they remain in the arteries, are never actually separated; and when they are, their separation is made, by the recess or going off of the Phlegme into the stomach and guts. And if any part of the Phlegme should accompany the blood into the Liver; the Liver would alwayes be inevitably obnoxious to great obstructions, such as would soon render it unfit for the office, by Nature assigned unto it.

Thirdly, the Bile certainly is more firmely united to the blood, than the Phlegme; as being essentially radicated in the serous part thereof, so that without some further preparation, it cannot be easily severed from it. And therefore it was requisite, that the Bile should be carried about by those ambages of the stomach and gutts, that by passing through those intricate meanders, it might acquire some disposition preparatory to its succeeding separation. Now, that which gives it this previous disposition, is a peculiar Fermentation, which it undergoes in the vessels leading it along into the trunck of the Vena portæ: it being most undeniable, that the speediest means in Nature, for the separation of impure humors from pure, is by Fermentation, as may be sensibly exemplified in Wine and Beer, which

are

are soon defecated by the help of Fermentation, but never without it. These Reasons, therefore, make it evident, that Nature was guilty of no oversight or rashness, when she ordained, that the Bilious Humor should be thus carried about through such indirect and long wayes, before it arrive at the Liver; seeing that circulation doth make its separation afterward both the more safe, and more easie.

12. Why the Blood is not carried immediately out of the trunck of the *vena portæ*, into that of the *vena cava*; but through the various meanders in the Liver.

Nor did Nature play the wanton, or supererogate, when she contrived, that the blood should be carried along through all those intricate labyrinths in the Liver; forasmuch as if the blood were to be infused into the trunck of the vena cava, by some vessell immediately and directly tending from the trunck of the vena portæ, the Bilious humor, being not yet separated from it, would necessarily pollute and corrupt the whole mass of blood. To avoid that inconvenience, therefore, was it requisite, that the blood should be first diverted into the Liver, and therein defecated from its remaining impurities, before it be permitted to enter the vena cava.

13. And why it is transmitted through the *Parenchyma* of the Liver.

When it is brought into the Liver, it doth not pass through the capillary branches of the vena portæ, into the extremities of the capillary branches of the Vena cava, immediately or *per Anastomoses*, as was long believed and taught by Anatomists; because we have the testimony of our eyes, that there are no such *Anastomoses*, or mutual Inosculations betwixt the extremities of those vessells: but, it is first percolated,

percolated through the Parenchyma or very substance of the Liver. Now, to what end is it so percolated? That percolation must certainly be in order either to some *Alteration*, or to some *Separation*. It cannot be in order to any *Alteration*, because no such thing can be imagined to be effected in the Liver, since the Liquor passing through the Liver, as it came-in blood, so doth it go out blood. It must, therefore, conduce to the *separation* of something from the blood. And that something can be nothing but the *Bilious Excrement*; because all other Excrements are separated, before the blood arrive at the confines of the Liver: and because no other Excrement can be found therein. Which consideration is alone sufficient to evince, that *the Office of the whole Liver, is to receive the blood out of the vena portæ, to purge it from the Bilious Excrement, and to discharge it so purified into the vena cava, thence to be conveyed into the Heart.*

As for the *Manner* how this excellent work of Purification is performed in the Liver; for the better understanding the same, we are to observe.

14. That the *Parenchyma* is the *Principal* part of all the Liver.

(1) That the *Parenchyma is the Principal part among all those many, that make up that ample and curiously contrived organ of the Liver.* In particular, the *Ligaments* of the Liver serve only to establish, or hold it firme in its natural position; the *Coat* investeth it; the *vena Portæ* brings the blood into it; the *Capsula Communis* is inservient to the distribution of the same blood, through

through the branches of the vena Portæ; the *Hepatick Artery* and *Nerve* serve partly to the better promotion of the blood into all parts of the parenchyma, and partly to the more quick and easie influx of the Bilis into the Porus Bilarius; the branches of the *Vena Cava* export the blood, after its purification; and those of the *Porus Bilarius* export the Bile, after its separation: so that it is manifest, that all these several parts are in some sort or other, mechanically inservient to the *Parenchyma*; and that the *Parenchyma is the sole part, wherein the separation of the Bile from the blood is made by an admirable artifice of percolation.*

(2) That this *Parenchyma* is a kind of *Streiner*, after a peculiar manner framed by Nature, for that separation, which can be no otherwayes effected, but by Percolation. For, whensoever a mixt Liquor is brought into a part, and in passing through that part severed into two distinct kinds, and so by distinct wayes effused out of it again; we may be certain, that those Liquors were severed each from other by percolation made in that part; and as certain that that part is a Percolatory Instrument. And since the very same is effected in the Parenchyma of the Liver, while the Bile is severed from the blood; we may well conclude, that that separation is made by percolation, and that the Parenchyma is a kind of *Streiner*. 15. And a kind of *Streiner*;

(3) That this *Parenchyma* being a lax and spongy substance, after a peculiar manner contexed, 16. Whose particles are con-

texed after a peculiar manner, and pores of divers sorts: in respect whereof, the Bile is therein separated from the blood, *mechanically.*

texed, and having various sorts of *pores*, where of some are in magnitude, figure and situation, particularly comparated for the reception of the impure blood, effused out of the extremities of the capillary branches of the *vena portæ*; and others in like manner particularly comparated for the reception of the minute particles of the Bilious Excrement, and the transmission of them into the extremities of the capillary branches of the *Porus Bilarius*; and others again particularly comparated for the reception of the minute particles of the pure blood, and the transmission of them into the extremities of the capillary branches of the *vena cava*: we say, these things being so, it is reasonable to conceive, that after the impure blood is brought into the pores of the *First* sort, the particles of the Bile are impelled into those of the *Second*, and through them into the extremities of the capillary branches of the *Porus Bilarius*; and the particles of the pure blood into those of the *Third*, and through them into the extremities of the capillary branches of the *vena Cava*; so as the separation of the Bile from the blood, is made in the parenchyma of the Liver, only by reason of this *diversity of its pores.*

17. The same inferred from 4 considerables: *viz.*

To encrease the verisimilitude of this Opinion, there occur 4. things not unworthy a serious remark, in this place; *viz.*

The equall distribution of the capillary branches of all the vessells in the Liver.

(1) That the Capillary branches of each sort of the vessells mentioned, are distributed equally into all parts of the Parenchyma; so that

that the Port-vein doth dispense the blood equally into all parts thereof; and the capillary branches of the *Porus Bilarius*, being likewise disseminated through all parts of the same, lye ready to admit the Bilious humor, as fast as it is separated from the blood; and the capillary branches of the *vena cava*, being also dispersed into all parts of the same, are ready to receive the pure blood, as fast as it is defecated from the Bile. Which is some document, that this whole work of purifying the blood from the Bilious humor, is performed in the Liver, only *Mechanically*, and that with the greatest facility imaginable: nor is it possible for the greatest wit of man, to imagine any fabrique more commodious for the effecting thereof, than this of the Liver is.

The Pulsation of the Vena Portæ within the Liver.

(2) That the *Vena portæ*, being entred into the body of the Liver, doth acquire a certain *Pulsation* (though weak and less perfect than that of an Artery) by the benefit partly of the *Capsula communis*, that includeth it, and partly of the *Arteria Hepatica*, that accompanieth it. For, being included in the same common case with the *Arteria Hepatica*, it must necessarily be compressed, in some measure, by the systole thereof; and again be relaxed, in the diastole: and by that means suffer a certain Dilatation and Compression alternately. And being so compressed, it must impell the blood into the parenchyma; and that blood must be driven on by the next succeeding blood: so as that the motion and distribution thereof is necessarily

continued by that impulse, without the necessity of any either *Similary Attraction*, or *Distinguishing Faculty*.

The assistance of that Pulsation, by the Hepatick Nerve.

(3) That the *Hepatick Nerve* may be conceived also to conduce somewhat to that Pulsation of the *Vena Portæ*. For, that Nerve also is included in the *Capsella Communis*, and no less distributed upon the same, than upon the branches of the *Porus Bilarius*. And, therefore, when the *Arteria Hepatica* is dilated, this Nerve, as being contiguous to it, must be somewhat compressed; and so irritated to make some small Contraction of it self: which being impossible to be effected, without a proportionate constriction of the *Capsula Communis*; it comes to pass, that the *Vena Portæ* included in the same *Capsula*, suffereth a constriction, at the same time.

The Resuscitation of *Vitality* in the blood, in the branches of the *Vena Portæ*, within the Liver; and a new *Fermentation* thereof, prævious to the separation of the Bile.

(4) It is probable, that this Pulsatile motion of the *Vena Portæ* within the Liver, doth cause some new *Fermentation* of the blood, and redintegrate the decayed *Vitality* thereof, in such a proportion, as may be sufficient to vivify the *Parenchyma* of the Liver, and conduce to the more ease and speedy separation of the Bilious impurities therein: especially considering that the Spirits of the blood brought in, are hindered from flying away (as they usually do through the thinner coats of the veins) by the thickness of the *Capsula Communis*, and so kept together to resuscitate the Mication and renew the Vitality thereof. That this is so, may be in part inferred from hence, that the Vital

Vital Spirits can be no otherwise communicated to this Parenchyma; the *Arteria Hepatica* being wholly distributed upon the *Capsula Communis*, and the branches of the *Porus Bilarius*, but never touching the Parenchyma with so much as one small surcle. Now there being no vessel that brings blood into the Parenchyma, but only the *Vena Portæ*; that Parenchyma must of necessity be deprived of all Vitality, unless we allow the blood, brought by the *Porta*, to recover its vital disposition, by the means of the Pulsation caused in the *Porta*, and the excitement of a new Fermentation from the restraint of the Spirits. For, without the influx of vitall blood, no part can be vivified: and certain it is, the Parenchyma doth receive no blood, but only from the *Vena Portæ*. This Resuscitation of the Vitall Spirits in the blood, brought into the Liver, may be adumbrated by the example of the heart of a Viper, or other Animal of like vivacity. For, the Heart being cut out of the Viper yet alive, and placed upon a table, doth a good while retain its pulsation; and as that motion begins to decay, by reason of the consumption of the Vitall Heat, if you but drop some warm liquor upon the then languishing heart, it will instantly revive, and beat again, untill it grows cold. And such doubtless is this small spark of life reenkindled in the blood contained in the *Vena Portæ*, within the Liver: which though but small, may yet be sufficient both to enliven the Parenchyma, and to excite some gentle Fer-

mentation in the blood, conducible to its purification in that place.

Now, to bring all this into a narrower circle; if we reflect upon the Equall Dissemination of all the foresaid vessels through all parts of the Parenchyma; upon the Pulsation of the Venà Portæ, within the limits of the Liver, whereby the motion of the blood is made more strong and quick; upon the promotion of that pulsation, by the Hepatick Nerv spontaneously contracting it self, after every diastole of the Hepatick Artery; and lastly upon the resuscitation of Vitality in the blood, and its renewed Fermentation (which always precedeth the separation of any humor from the blood): we say, reflecting upon these things, we may plainly understand, with how little of difficulty the bloud is impelled into all parts of the Parenchyma, and therein separated from the Bilious impurities, only by reason of the Diversity of Pores in the same Parenchyma, according to a *MECHANICAL* way or method. Which was the difficulty that required to be removed.

18. The various Manners of the *Excretion* of Excrements, after they are separated and collected.

When Excrements are separated, they must be Excluded; and therefore, having investigated the manner of their separation from the bloud, it is requisite that we say somwhat of the Manner of their *Excretion*. For albeit there be no Excretion, but what is effected immediately by *Pulsion*; yet doth that Pulsion arise from *various causes*. In particular, *One* sort of Excretion is made by *simple Propulsion*;

pulsion; as that of the Serum through the substance of the Kidneys, that of the Bile into the bladder of Gall, and into the *Porus Bilarius*, and of the Phlegma into the Guts. *Another* is, from the *Rarefaction of the Excrements themselves*; as when the Serum, flowing together with the blood in the arteries, is rarefied by heat, and breaks forth into the habit of the body, whence at length it is excluded in sweat through the pores of the skin; and when the watery part of the blood is by way of Exhalation transmitted through the coats of the smaller arteries, and collected in the Lymphe-ducts. And a third sort of Excretion is made, meerly by the *Spontaneous Contraction of the Parts Expelling*; such is that of the Bile out of the bladder of Gall, into the *ductus communis*; of vitious humors out of the stomach, by vomiting; and of the Urine out of the bladder, *&c.* So that we see, there is as little need of any *Attraction*, toward the Excretion of Excrements, as there was toward their separation from the blood.

19. The particular Manner of the Excretion of the *Bile*.

To Explicate the Manner of the *Excretion* of the *Bile* somewhat more particularly; we note, that the *Porus Bilarius* is filled with that humor, by its capillary branches disseminated into the greatest part of the Parenchyma of the Liver: and the *Vesicula Fellis*, by its Fibrous roots, that are likewise disseminated into the rest of the parenchyma. And when these two *Receptacles* are thus filled with this humor, even to distention; then, being irritated or molested

lested by that burden, they contract themselves, and so squeez out so much thereof, as exceeded their natural capacity: the *Vesicula Fellis* exonerating it self by the *Meatus Cysticus*, and the *Bilarius Porus* by the *Ductus communis*, out of which the excrement is convaid, by the oblique insertion, into the Guts. Which *Irritation* and *contraction* of these Receptacles, is the cause, why the Bile doth not continually and by drops destill out of the *Ductus communis* into the Guts, as the serum doth into the Ureters: but is as it were eructated *by intervalls*, and in *good quantity at a time*; those concave and membranous parts never contracting themselves, but only when they are above measure distended by a redundancy of the humor contained in them; and the efflux of the humor depending wholly upon that their Contraction.

20. And the Cause thereof,

That these parts do thus *Contract* themselves, is inferrible from hence, that all sensitive parts (among which the *vesicula Fellis* may be accounted, in respect it enjoyeth a small Nerve derived from the sixth conjugation) are capable of *Irritation*: and therefore, whenever they are distended beyond their natural rate, or otherwayes molested; they begin instantly to make some resistance, and reduce themselves to their due laxity, by ex-pressing what was offensive to them; and if the parts thus irritated, be concave, membranous, and fibrous, it is necessary, that their resistance be made by a Contraction of all their Fibers, whereby their cavi-

ty

ty is lessened, and some part at least of the humor distending them, is expelled. The Receptacles of the Bile, therefore, being such parts; they must have such a motion of *self-Restitution*, upon the like occasion.

Digression.

21. *PARADOX.* That we have a certain *Natural* Feeling wholly distinct from the *Animal*, and independent upon the Brain.

Here (me-thinks) I perceive my Reader to put on the cloudy aspect of dissatisfaction, and to arrest me with this *curious* scruple, saying; *Doth not this Irritation and spontaneous Contraction of Membranous and Nervous parts, when they are molested, imply a certain sense in them, distinct from the sense of Feeling or Touching, and independent upon the Common sense, or Brain?* For, whatever is any wayes moved by it self, in avoydance or resistance of what is offensive to it; must be endowed with a sense, whereby to discern that offensiveness: according to that rule, *Quicquid contra irritamenta & molestias, motibus suis diversis nititur; id sensu præditum sit, necesse est.* But we are not conscious to ourselves of any such sense within us (as we are of all our Animal senses) whereby those parts are made sensible of their irritations; and therefore it seems, you have imagined one sense more than Nature hath made.

For the solution of this Difficulty, therefore, we *Answer*; that those Motions and Actions, which Physicians call *Natural* (because they are not instituted by the Will; but done even against it, and cannot be moderated, accelerated

ted, retarded, or suppressed, *ex Arbitrio nostro*, at our pleasure: and so have no dependence upon the Brain, that is the Common instrument of all the senses) these motions and actions, we say, are not yet made without some *sense*, naturally inhærent in the parts moved. For instance; we are certain, that in palpitations, tremblings, syncopes, swooning fits, and other Cardiacal symptoms or affections, the *Heart* doth variously move, and agitate it self; as being offended with something preternatural and noxious to it, and irritated to resist and repell the same: and this in respect only of some sense or feeling, by which it discerneth what is incommodious and harmfull. The *stomach* and *Guts*, in like manner, being oppressed and provoked by vicious humors, instantly rise in armes, and raise impetuous vomitings, nauseousness, convulsions, fluxes of the belly, and the like motions, for the expulsion of their enemies: and as we have it not in our power, to excite or suppress those commotions; so have we no particular cognisance of any such sense, which should extimulate those parts to begin and continue them. Truly, we cannot but wonder, as oft as we observe the effects of Antimony infused in wine, and taken into the stomach. It is not our Tast, that doth distinguish the tincture of the Antimony, from the wine; nor are we sensible of any disagreeableness therein to our nature, while we are swallowing it down: and yet in the stomack there is a certain sense, that discerns the offensive-

ness

neſſe of that draught, and quickly engageth the ſtomach to raiſe and contract it ſelf, and to eject it again by vomiting; nor will it ever ceaſe, till it be wholly diſcharged. Conſider, how even the *Fleſh* it ſelf doth preſently diſtinguiſh a poyſonous puncture, from a ſimple one; and how ſoon it contracteth, condenſeth and fortifieth it ſelfe, to expell the venome, whereupon enſue ſwelling, inflammation, and great pain in the part pricked, as is obſerved in the ſtinging of Bees, and Hornets, and Scorpions, and the biting of Spiders, Vipers, and other venenate Animals; and all this meerly from ſome ſenſe, which teacheth the fleſh that difference, and excites it to make reſiſtence. Conſider further, how the Contorſion, Falling downe, Aſcent, ſuffocation and other violent Agitations of the *Womb* in women; proceed not from the brain, or Common ſenſe, but from a *Natural ſenſe* inhærent in that part, without which it could not be provoked to thoſe impetuous ſtrivings and motions. For, whatever is wholly deſtitute of ſenſe, is wholly uncapable alſo of being irritated to performe any action or motion, in order to its ſafety. Nor can we, indeed, otherwiſe diſcern what is Animate and ſentient, from what is Inanimate and void of ſenſe; but only by ſome *Motion* excited in it, by ſomething moleſting and irritating it: which Motion doth continually both follow and argue ſenſe.

To evince this *Natural* ſenſe yet further, we

ſhall thus reaſon. We find in our ſelves, that we have Five External Senſes, by which we perceive objects without us; but, becauſe we do not perceive our perception, by the ſame ſenſe, by which we perceive objects (for, we ſee with our eyes, but do not by them perceive that we ſee; but by the mediation of another internal ſenſe, or ſenſitive organ, the Brain, by which we judge of all objects offered to the External ſenſes): therefore is it manifeſt, that the common ſenſory is the Brain, which together with all its Nerves, and external organs annexed to thoſe nerves, ought to be held the adequate Inſtrument of ſenſation. And we may fitly reſemble it to a ſenſitive Root, which ſhooteth forth many Fibers or ſtrings, whereof one doth ſee, another hear, a third taſt, a fourth ſmell and the fifth feel.

Nevertheleſs, As Experience aſſureth us, that there are ſome Motions and Actions in us, whoſe regiment or moderation is no ways dependent upon the Brain; and therefore, by contradiſtinction to voluntary or Animal motions and actions, they are named *Natural*: So alſo doth Reaſon teach us, that we have a certain ſenſe of *Feeling*, which is not referrible to the Common ſenſe, nor communicated to the Brain, and of which we take no cogniſance, but by the various effects and commotions that it cauſeth in our bodyes. For, in this Senſe, we do not perceive that we feel; but as it fares with men diſtracted, or otherwiſe agitated with any violent paſſion of the Mind, who

who neither feel pain, nor take notice of objects offered to their senses: so is it with us in this Sense, which operating without our knowledge, is therefore to be distinguished from the Animal sense, and may be properly enough called a *Sensation without Sense*. And certainly such as this, is that sense observed in *Zoophytes* or Plant-Animals; as the sensitive Plant, the Boramets or Vegetable Lamb of Tartary, Sponges, *&c.*

We know, there are many Animals, that have both sense and motion; and yet have no brain, or Common-sense, as Earthworms, Caterpillers, Silkworms, *&c.*; and that there are some Natural Actions in us, which are performed without the influence or help of the brain. As Physitians, therefore, teach us to distinguish such actions Natural, from actions Animal: why may not we, with equall reason, distinguish the *Feeling Natural*, from the *Feeling Animal*; so as to refer one to the brain the other not.

We know moreover, that it is one thing for a *Muscle* to be moved or contracted *Spontaneously* (as in Convulsion); and another, for it to be moved *Voluntarily*, or with various regulated contractions and relaxations, in order to the performance of some action intended, as Progression, or Apprehension. The Muscles, certainly, or Motory-Organs, are, in cramps and convulsions, moved spontaneously, upon their irritation by some acrimonious vapours, or other injurious cause; no otherwise than

the body of a Fowl is moved, after the head is cut off. For as the body is tumbled up and down, and agitated by various convulsive motions of the feet and wings, yet such as are wholly confused and irregular, and of no effect either to progression or to apprehension, because the power and influence of the brain is extinguished; by the government and moderation whereof, those motions were formerly regulated either to progression, or flying: so in Convulsions, our Muscles are contracted, and our members variously agitated with irregular and ineffectuall motions; because those motions depend upon a natural sense only, without the regulating influence of the Brain, which taketh no cognizance of the injuries done to the Muscles, nor of the sense which irritateth them.

These things duly considered, Reason adviseth us, henceforth to lay aside that opinion of *DesCartes*, and his disciple, *Regius*, (both great Philosophers, and in many other things worthy to be followed) that the influx *of Animal spirits by the nerves, is necessary to the performance of all Naturall Motions and actions done in the body*: and to take up this more probable one of *Dr. Harvey*, that *each Natural action is effected by the part doing it, meerly in respect of a certain sense, whereby it feeleth what is troublesome and injurious to it selfe, and so is irritated to excite such motions of it self, as may conduce to its vindication; and this, without any influx or regiment of the Brain, or Common sense, at all.*

We

We might have added further, out of the same *Dr. HARVEY* that all Motions in the body, are derivative from the *Vitall Influence of the Heart*, and wholly dependent thereupon; because, no part is longer capable of this Natural sense, than while it is irradiated and enlivened by the Vitall Spirits or blood flowing from the heart; for no part once mortified, *i.e.* no longer participant of the Vitall influence, can have any sense, or be irritated to motion. Besides, it is not unreasonable to conceive, that the strength or *Tone* of each part doth mostly consist in its enjoying a due proportion of Vitality: and if that Tone or firmeness be viciated or diminished (as soon it must, if deprived of that requisite influx), that part becomes languid, dull, and hardly capable of irritation But this noble speculation requires to be handled with more exactness, than the narrow limits of a short Digression will admit of: and we have already said more than enough to assert, that all parts of the body have a certain Naturall sense of Feeling, distinct from the Animal, and wholly independent upon the Brain; which was the Probleme proposed. ¶.

OF

OF RESPIRATION.

Exercitation the Eighth.

Of Respiration.

Article 1. The Connexion of this Exercitation, to the precedent.

THE Chain of Nature, by which ſhe connecteth various Operations conſpiring to one and the ſame End, brings us in the next place to diſcourſe of *RESPIRATION*; betwixt which and the *Pulſation* is a manifeſt affinity. For, theſe two Actions or Motions, as they are inſervient to the conſervation of the Lamp of Life, and the Generation of Vital Spirits; ſo do they both conſiſt of a Dilatation and Contraction; the one of a Diaſtole and Syſtole of the Heart and Arteries, the other of a Diaſtole and Syſtole of the Breaſt and Lungs.

Now this *Affinity*, hath given occaſion to many Phyſicians to conceive the Diaſtole and Syſtole of the Lungs, to be Synchronical or coincident with the Diaſtole and Syſtole of the Heart; and to refer both their motions to the ſame cauſe and Original. But, They have groſsly erred, in confounding things ſo manifeſtly different. For

2. The Diſparity

(1) There are many ſorts of Animals, that have

have Hearts, but no Lungs. (2) The Dilatations and Contractions of the Heart, are clearly distinct from those of the Breast and Lungs; as is evident from hence, that they are not synchronical, *i. e.* made and terminated in the same periods and times; one complete Respiration taking up more time, then 4 or 5 Pulses: and this in all Animals that have both Heart and Lungs.

betwixt *Respiration*, and *Pulsation*; both as to their *Times* or periods, and as to their *Uses*.

(3) The Motion of the Heart and Arteries is much different from that of the Lungs, as to their Uses.

For, *First*, if the Pulse and Respiration have one and the same Final cause, and that (as these men have assumed) the Arteries take in the ambient aer through the skin, at every Diastole; and exclude it again the same way, together with the Fuliginous Exhalations of the blood, in every systole; and that in the space of time intermediate betwixt each Diastole and Systole, they contain both the inspired aer, and exhalations: then must we renounce both the doctrine of our Master *Galen*, that in the arteries nothing is contained, but the bloo d; and our owne experience, that confirms it.

Secondly, if the Arteries were (as the Lungs are) filled with aer drawn in by their extremities, and that the quantity of aer attracted, were proportionate to the magnitude of each pulse, or to the greater or lesser dilatation of the arteries: then, if, while the pulse is great, the whole body were immerged into a bath of water or oyle, it would necessarily follow, that the

the Pulse would become much smaller, or much slower; because it is highly difficult, if not wholly impossible, that the ambient aer should pass through the bath, into the pores of the skin, and so into the arteries.

Thirdly, since all the Arteries, as well those that lye deep in the body, as those terminated in the skin, are moved with equal velocity, and at the same time; it is not possible, the ambient aer should as freely and swiftly pass through the habit of the body, into the profoundest arteries, as into those contiguous to the skin.

Fourthly, it is not credible, that Whales, Dolphins, and other Cetaceous Animals, that have Respiration, can draw aer into their arteries, at every diastole, through so vast a mass of waters, as is from the bottom to the top of the sea.

Fifthly, if in their systole, the Arteries expell the fuliginous exhalations of the blood, through the pores of the skin; why should they not expell also the vital spirits, that are far more subtile and fugitive, than those supposed Exhalations can be? Nature certainly hath made no such Colatory, as should retain the thinner spirits, and let the grosser fumes pass through. Nor is it yet sufficiently proved, that there are any such Fuliginous Exhalations generated in the heart and arteries, and afterward excluded partly by the Lungs, partly by the Arteries, in their Contractions; as are vulgarly believed. For, the blood suffereth

only

only a simple agitation, or conquassation in the ventricles of the heart, and a propulsion in the arteries: and that it can produce such an abundance of sooty fumes from the blood, as Physicians have talked of; is not easie to conceive. Truth is, the blood, by reason of its heat and swift motion, doth emit some Halitus, or vapours (which streaming through the coats of the smaller arteries, are received and condensed into a thin limpid liquor by the Lymphe-ducts) but is it therefore necessary, that it should emit Fuliginous exhalations? We confess also, that there is a certain thin Excrement of the blood and humors, which passeth through the habit of the body; but, that it should be discharged in thick clouds of exhalations, in every systole of the arteries, this is plainly impossible: because at that time the coats of the arteries are constringed and compressed, and there might be an easier egress for them, in the Diastoles, when the cavities of the arteries are dilated. So that among these many Arguments, there is not one, but doth clearly detect, and throughly refute the Error of those Men, who have confounded the Uses of the Arteries, and Lungs, of Pulsation and Respiration.

This capital Error eschewed, we may the more safely progress to explicate the nature of Respiration, as a thing in sundry particulars distinct from Pulsation, though perchance instituted by Nature, as in some sort subservient to the vital Faculty. And, that we may pro-

ceed methodically, it is requisite we consider (1) the *Manner* of Respiration; (2) the *Efficient* Cause; and (3) the *Final* Cause, or *Use* of it.

Concerning the First.

3. *Respiration* described.

Respiration [Ἀναπνοὴ] is an Action of the Breast and Lungs consisting of two contrary motions alternately successive, or of two parts, *viz.* (1) *Inspiration* [Ἐμπνοὴ] in which the ambient aer is impelled into the Lungs and chest, at that time dilated: (2) *Exspiration* [Ἐκπνοὴ] wherein the same aer is again expelled out of the Lungs and Chest, those parts spontaneously contracting or compressing themselves.

Concerning the *Inspiration*, the grand Question is, *Whether the Breast and Lungs are dilated, because they are filled and distended with the aer; as a bladder is distended by aer blown into it: or, Whether they receive in the aer, because they are dilated; as a pair of Bellowes is filled with aer, only because it is dilated or opened by external force?*

4. The Efficient Cause of *Inspiration*, is the Dilatation of the Breast, impelling the ambient Aer into the Lungs.

To solve this difficulty, in a word, we say, the Breast is first dilated, before it can be filled with aer, and that Dilatation or heaving up of the brest is the cause of the airs rushing in at the mouth and nostrills, down the *Aspera Arteria*, or wind-pipe, into the Lungs. For, since there is no vacuity (at least no Coacervate one) in the world, no body can be moved out of its place, but the next body must give way, and the next to that likewise give back, till such a part

part of space as is adequate to the dimensions of the body first moved, be made to receive it, and the space which it abandoned, be again fully possessed by another body succeeding into it: we say, since this is necessary, it is manifest, that the aer next incumbent on, or contiguous unto, the Breast and Abdomen being urged and impelled by the breast, while that is dilated or expanded, is forced to give back, and press the aer next to it, which likewise drives back the next aer, untill at length the compressed aer wanting room to retreat into, and endeavouring to avoid further compression, (its own Elater ingaging it thereto) rusheth into the breast and there possesseth that room or part of space, which was left by the breast, when it began its motion. So that so much aer is impelled into the breast, as is driven out of its place by the superfice or outside of the breast, during its expansion or dilatation.

As for the *Attraction* of Aer into the Lungs, *ad fugam vacui*; it is a meer dream; as well because all motion is by *Impulsion*, as because Nature doth not abhor vacuity *primario* or *ex se*, but only *ex Accidente*, or in respect of the confluxibility of the insensible particles of Fluid bodyes, as we have elsewhere amply demonstrated. *In Physiolog. Epistro-Gassendo-Charlionia. lib. 1. cap. 5 pag. 40.*

And if there were any Cause to be found, that might blow the aer into the breast, as it is blown into a bladder, so as to distend it; or at least, if the aer could be conceived to enter

into the breast spontaneously, or of its own accord, without impulsion, so as to force, or heave up the same: then indeed, would the Comparison betwixt the dilatation of the breast, and that of a Bladder, by wind blown violently into it, hold good, and we should not need to seek further. But, there being no such insufflating cause assignable; and it being ridiculous to imagine the aer should spontaneously move it self, so as to flow uncompelled into the cavity of the Chest (as is manifest not only in dead men, into whose breasts, though their mouths and nostrils are wide open, the aer doth not croud it self: but also in living men, when they at their pleasure keep their breasts compressed, or hold their breath, as the vulgar phrase is), it seemes much more reasonable to explain the reason of Inspiration, by that other similitude of the flux of aer into a pair of Bellows; there being no other difference betwixt the repletion of the Chest, and the repletion of a pair of Bellows, with aer, but only this; that the Bellowes are opened by an externall force, and the Chest is dilated by an internal.

5. And the cause of *Expiration*, is only the spontaneous contraction of the Breast.

And as for the *Exspiration*, that is evidently from the compression of the breast and Lungs, which is the naturall motion of Restitution For, the Dilatation being an action, whereby the parts of the Chest are distended into a position more large, than is natural to them; the Contraction seemes to be nothing else, but a certain falling down or relaxation of the parts

parts distended, whereby they spontaneously return to their natural position, and such as they hold in a dead body; and this not onely in the Lungs, but also in the Diaphragme, which in dead bodyes is not extended downward to the stomach and guts (as in inspiration) but riseth upward toward the Lungs and Heart. But if it be here demanded, whether Inspiration, or Exspiration be first; we answer that it is necessary that the aer should be first inspired, before it can be exspired; and every ANIMAL dyes *Exspirando*, in Exspiration.

Concerning the *Second*.

6. The Dilatation of the Breast and Lungs, not from any Motive Faculty congeniall to the Lungs.

The Enquiry is, *By what cause the breast and Lungs are so dilated*, as we have asserted? And this, indeed, is a Difficulty not so soon resolved, as proposed; for, besides the obscurity of the thing it self, we find our selves benighted with the various opinions of Authors. Some wil have, that the Lungs are endowed with a certain *Faculty of Dilating themselves*; and so elevating the whole breast: as the Heart hath a pulsifick faculty, by whose virtue the ventricles contract themselves in each Systole. And, hereupon was it, that *Aristotle* (the Author of this opinion) doth compare the Lungs to a pair of Bellowes, as if they did of themselves first attract the aer, and then emit it again. But, though it be true, that the Lungs are filled with aer, and emptied again, or elevated

and

and depressed alternately, as Bellowes are; yet is it doubtfull, whether (as the hand which moves the bellowes, by opening and shutting them, is the cause both of the influx and efflux of the aer in them) there be not some other part of the Chest, besides the Lungs, which being first dilated and contracted, is the cause, why the Lungs are opened and shut; or more plainly, *whether the expansion of the Lungs be from an ingenite Faculty*? And, that the Lungs have no such Ingenite Motive-Faculty, is sufficiently manifest even from hence, that their motion is alwayes conforme to that of the Diaphragme, and from hence, that we can suppresse, accelerate, or retard our respiration, as we please.

7. Nor from the impulse of the blood out of the heart into the Lungs.

Others derive the motion of the Lungs from the *Heart*, or rather *the blood expelled out of the right ventricle of the heart, through the Vena arteriosa into the Lungs, and so lifting them up.* But this is erroneous, because (1) the efflux of the blood out of the right ventricle is caused by an ordinary motion purely natural to the heart; whereas (as we said even now) Respiration is sometimes arbitrary: (2) the cause of pulsation and Respiration would then be not onely one and the same, but those motions also would agree in their times and periods; whereas scarce four, nay six, pulses are equal in time to one single Respiration: (3) the blood doth not stay long enough in the vessels of the Lungs, to keep them elevated all that while they are distended; but is in continual motion,

tion, and in a moment circulated by the Arteria venosa, into the left ventricle of the Heart: and where it is retarded in its course, by any misaffection either in the capillary vessels, or in the substance of the Lungs (as it many times happens, in the disease vulgarly called, the Rising of the Lights) it causeth extream difficulty of breathing: (4) in great Apoplexies, while the pulse continueth good and regular, the Respiration many times ceaseth.

8. Nor from the motion of the Muscles of the Thorax.

Others will have it, that the Lungs borrow their motion from the *Thorax*, or *Chest* containing them; but the reason which detaine us from assenting thereto, is, that after the chest is cut quite open, the Lungs continue their motion for a good while, and strongly: which were impossible, if they derived their motion from the chest.

9. But from the *Diaphragme* moved by a congenite Faculty.

Now it being evinced, that the Lungs are not moved either by themselves, or by the Heart, or by the Thorax, it remains, that they must be moved by some other part in the Breast, in which as in the first original, the motion of Inspiration doth begin: and this part seems to be no other, but the *Diaphragme*, and that for these reasons. (1) In wounds, or perforations of the breast, the Lungs instantly falling together, as it were close themselves (for some short space) while the Diaphragme is still elevated and depressed alternately, contracting and againe relaxing the ends of the spurious ribbs, and cartilages to

which

which it is annexed: whence it comes, that the aer rusheth violently into the cavity of the chest, and upon the elevation of the Diaphragme, is driven out again, through the wounds with impetuosity sufficient to blow out a candle. (2) Every man, in Inspiration, feels the Thorax to be dilated, and the whole Abdomen lifted up, and the ends of the lower ribs to be drawn inward: the Diaphragme being extended downward, with its middle part crowding down the stomack, liver and guts, and with its circumference or extream parts contracting the ribs.

(3) Allowing the Diaphragme to be the *primum Movens*, among all parts inservient to inspiration, we may easily understand, why the Respiration becomes more frequent and remiss, when the stomach is full, and when the Aer is made more dense, than ordinary, by fogs and thick exhalations. For, in the former case, the Diaphragme hath not room enough to expand it self downward, as it ought, and so is compelled to compensate the smallness of its motion, by the frequency of it; and in the latter, the Lungs are so prepossessed with gross vapours, as that they cannot admit much aer at a time, and therefore the Diaphragme is necessitated to repeat its motions so much the oftner. (4) In Apoplexies (unless they be fatal) though the Respiration be almost insensible, yet the motion of the Diaphragme is continued; as may be perceived by the gentle motion of the Chest. (5) Respiration is more

perturbed

perturbed and vitiated, by diseases of the Diaphragme, than by those of any other part of the breast: and it hath been observed by *Vesalingius* that a *Steatoma* grown upon even the carneous part of it, caused extreme difficulty of breathing. Now, these are the Reasons that have induced us to believe, that the *Motion of Respiration begins in the Diaphragme*; which being a kind of Muscle of a peculiar figure, substance, position, and action, may as well be conceived to be extended by virtue of a certain peculiar and *ingenite Faculty*, as the Heart is by a Pulsifick Faculty: so that we may conclude the same to be the prime and principal instrument of Respiration Natural or Gentle.

Syntagm. Anatom. p. iij.

We say *Natural or Gentle*, by contradistinction to Respiration *Violent*, or *Arbitrary*. For, allowing of *Galen's* triple difference of Respiration, *viz. Free and Gentle*, *violent*, and *more violent* or *sublime*: we conceive the *First* to depend upon the Diaphragme alone; the *Second*, to require a concurrence of the Intercostal Muscles, of which the interior serve to contract, and the Exterior to dilate the Chest; and the *last* to be effected by the Diaphragme, Intercostal, and Pectoral Muscles, all being set a work, and combining together to the motion. And, as for Respiration *voluntary*, such as we can at pleasure suppress, accelerate, or retard; that is manifestly by the help of the Intercostal Muscles, there being no other instruments of Motion voluntary, but the Muscles; and no other Muscles immediately conducing

10. Yet as well the *Intercostall*, as *Pectoral* Muscles are allowed to conspire with the Diaphragme, in Respiration *violent* and *Arbitrary*.

ducing to the contraction and dilatation of the breast, *ex arbitrio nostro*, but the Intercostal.

Concerning the *Third*, *viz.*

The *Final Cause*, or *Use of Respiration.*

11. The *Final* Cause of Respiration, n ot the *Refrigeration* of the Heart, or Vital Flame: but the *substitution of the blood*, which by the admission of Aer, is made the more convenient Fewell for the Lamp of life, and matter of the Vital Spirits.

The most General opinion (to omit all others, as less considerable) is, that the principal use of Respiration, is for the *Refrigeration of the Heart*. Which though very ancient and plausible, is rather meerly Conjectural, than Areopagitical or demonstrative. For (1) As aer over-hot is injurious to the heart, so is aer over-cold: and as aer moderately cold is beneficial to the heart, when it is excessively heated; so is aer moderately hot, beneficial, when the heart is too much cooled. But, while the heart is in good temper, then the aer most agreeable to it, is neither hot, nor cold, but temperate. (2) It is inconsistent with the prudence of Nature, to make the natural heat of the heart so intense and excessive, as to require perpetual ventilation with cold aer: when it had been much easier for Her, to have kindled a more gentle fire therein at first, than to bring cold aer to the hearth with so much adoe, to keep it in moderation ever after. And, in case that Fire should chance, at any time, to grow less, or languish (as it often doth, in extreme cold aer, many men being frozen to death in *Green-land*, *Russia*, and other Northern Countries) what provision hath Nature made for

for the reaccension or instauration of it? (3) If it be only the Cold of the aer, that is beneficial to the heart; then, certainly, the Water, (which is much colder than the aer) would more conveniently satisfie that necessity in Fishes, which yet cannot live without aer. (4) In persons of cold and Leuco-phlegmatique constitutions, there would be no need at all of Respiration; especially in frosty weather, when the heart hath as much want of warmth, as of cold, and more too. We confess, indeed, that at such times, our Respiration is more slow and rare, and in the heat of Summer, more quick and frequent; as it is also in Fevers: but the reason hereof is, that in Summer, the blood being made hotter, is sooner subtiliated into spirits, and those spirits faster consumed and dissipated; and so requires more aer to promote the subtiliation and inflammability of its spiritual parts. So that it should seem, the Aer is required rather as an Excitement, than as an hindrance to the vital Flame. We say, for the Excitation, or Accension of the Flame of life, by subtiliating the blood, and making the inflammable parts thereof more convenient Fewell for the same vitall Flame, and for the matter of the spirits, which being diffused through the whole body, serve to conserve and vivifie all the parts; no otherwise than Bellowes conduce to the accension of flame in wood.

12. The same exemplified by

For, as the Aer blown out of a Bellowes, doth promote the accension of fire, in wood,

the accension of flame in wood, by aer blown out of Bellowes.

or other combustible matter; not by reason of any Cold (for Contraries never generate each other) but by the subtility of its particles, and the vehemence of its motion, in respect whereof it both dissipates the ashes, that hinder the ingress of the fire, and impells the particles of the fire into the pores of the wood; so as that they penetrating more deeply into the substance thereof, invade and kindle all the inflammable particles therein contained: so doth the Aer brought into the Lungs, and commixing it self with the blood circulating through them, insinuate it self, by the Arteria Venosa, into the left ventricle of the heart; and there partly by its subtility, partly by its expansive motion, so conspire with the pulse of the heart, as to conduce to the rarefaction and subtiliation of the more thin and inflammable parts of the blood, that so they may be made both commodious fewell for the Fire burning in the heart, and also fit matter of the vital spirits. All the difference is, there are no Ashes made in the heart, the Flame thereof being more pure, than focal-fire, and subsisting in a matter as fine and subtile, as spirits of wine. Nor are there any sooty exhalations; such as arise from oyle burned in a Lamp: but such a Flame is perpetually revived out of the blood in the heart, as is made by the purest spirits of wine set on fire.

13. And inferred from the structure of the Lungs.

This Use of the Aer inspired, may be in some sort inferred from the very structure of the Lungs. For, to what purpose doth both the

Vena

Vena arteriosa, and *Arteria Venosa* divide and disperse into so many branches and surcles, throughout the lobes of the Lungs; unless it be to convey the aer brought into them (out of the *Bronchia*, or pipes derived from the Aspera arteria) together with the blood, into the left ventricle of the heart, there to excite the vital flame? For, certain it is, from the structure of these vessells, that the Aer doth not arrive at and enter the heart, pure and sincere (as it ought to do, in case it were to refrigerate the heart) but mixed with the blood returning out of the Lungs: which is the reason, why in the dissections of living creatures, no aer is to be found in the Arteria venosa, being, before it comes thither, throughly commixed or confused with the blood. Nor can we force aer into the heart, through the Lungs of a dead body; because the motion of the blood is then ceased. And this we conceive to be the Principal End, or Use of Inspiration.

14. The Use of Exspiration.

As for that of *Exspiration*, it seems to be no other but the explosion of the same aer formerly received; together with the *Halitus*, or vapours of the blood, that steam from it, while it is circulating through the Lungs. For, as to that Antique opinion, of the discharging of *Fulginous Exhalations* issuing from the heart; to the reasons by us formerly alleaged to discredit the Generation of them, we shall subjoyn two or three convincing ones, to disprove their Exclusion through the Lungs. (1) The motion of the blood out of the Lungs, by the

Arteria

Arteria Venosa, into the left ventricle of the Heart, being continual and strong; doth manifestly forbid any thing to come from the Heart, into the Lungs that way: and (2) the situation of the Valves in the same Arteria Venosa, doth as much. (3) That the Aer passing to the Heart, and the (supposed) Fuliginous exhalations issuing from the Heart, should be carried through one and the same vessel, by contrary motions; is insolent to Nature, and incompetent to the oeconomy of the body.

15. A *Probleme*, of the Respiration of the *Fœtus*, in the Mother's womb.

And here we aske leave to propose a *Problem*. Certain it is, that the *Foetus*, while in the Mother's womb, doth receive nourishment (not by the Umbilical Vessels, for in them nothing is contained, but Blood, which is not the Aliment of the parts; and the Umbilical Vein serveth onely to the Circulation of the blood, by bringing back to the heart, what the two Umbilical Arteries carried from it into the *Placenta Uterina*: but) by the *Mouth*, sucking in that milky liquor, wherein he swimmes: which *Hippocrates* long since, and *Dr. Harvey* of late, have undeniably proved. Now, this being so, doth it not seem necessary, that the *Fœtus should also have the use of Respiration*? For, since all *Suction* is by *Impulsion* (as we have elsewhere at large demonstrated) being caused only by the pressure of the thing sucked, by the Aer impelled in round (as we lately expressed, in the cause of the influx of the aer into the Lungs, in Inspiration) certainly,

ly, without the help of aer, the *Fœtus* cannot possibly suck in his nourishment. To this Reason (and we think it a weighty one) may be added, (1) the Authority of the *Divine old Man*, who in most expresse termes saith, ἡ τοῖσιν [viz. *Fœtibus*] ἄνω τὴν πνοὴν ποιέεται, τῷ τε στόματι, καὶ ῥισί, *Puer ab alto respirat, & ore & naribus.* (2) that Chickens breathe in their shells (through which the aer hath a more difficult passage, than through the secundines) and Fishes in the water. And as the Chicken pipes within the shell not yet broken; so hath it been observed and recorded by sundry learned and authentical Writers, that Infants have been heard to cry in their Mothers wombs: which were impossible, unlesse they enjoyed the benefit of Respiration. lib de Natur. pueri.

(3) The posture of the Child in the womb seems to assert the same. For, as there is an ample space betwixt the coats of the Secundines, and the Child, to the end that a sufficient magazine of milk for his sustenance, might be stored up, and conserved therein; so is not that whole space filled up with that Liquor, but in the upper part there remains so much space unpossessed by any thing but Aer, as is sufficient for so gentle a Respiration, as the Infant hath need of: just as in the blunter end of an Egge, we perceive a certain empty space after the Hen hath sate upon it. And lest the *Chorion* should at any time be corrugated or shrieveled up together, and so streighten or compresse either the Liquor, or the Infant;

Nature

Nature hath affixed the same to the *Placenta Uterina*, to the end, that adhering to the bottome or upper part of the womb, it might hang fast, as an Apple hangs by its stem, or as our Globes of Glass are hung up by strings to the Seeling of a room. So that the *Chorion* thus adhæring to the *Placenta Uterina*, which is fastned to the bottome of the womb, and the *Amnios* in like manner adhering to the *Chorion*, in the same upper part; and the lower part of each membrane being depressed by the weight of the Infant, and of the Humors contained in them: it thence comes to pass, that this Natural Machine both of the Child, and Membranes (though at first it were perfectly round, as the yolk of an Egge) is afterward made of an oval figure. For, though the *Fœtus*, sitting incurved or bowed forward, as much as possible doth keep himself in a round figure, because of taking up the lesse room (for he sits with his leggs crossed, his heels drawn up to his buttocks, his elbowes resting on his knees, one hand held up close to his ear, the other to his cheek, for the more firme and easie sustentation of his head) yet, in that situation he hath need of a Mansion of an *Oval Figure*, that swimming in liquor, he might keep his head above water, and at his pleasure take in his nourishment by his mouth, and also inspire the temperate aer surrounding his head, in the void space of the Secundines according to the opinion of *Hippocrates* newly recited. (4) Nor is the ingress of Aer into the womb impossible

ble. For, albeit the mouth of the womb, in pregnant women, be shut up, so as to exclude ones finger, or (as others will have it) a small probe: yet is it not so sealed or luted up, as to exclude the Aer; as may be inferred from hence, that many Femals have *superfœtations*, and more women (especially in this our moist Iland) are troubled with the *Fluor albus*, all the time of their Gravidation; neither of which could be, unless the *Cervix Uteri* were pervious: For, if there may be an ingress for the seed of the male after a former Conception; and as free an egress for the matter of the *Fluor albus*, all the time of the gestation of the Foetus: then, doubtless, *Hâc etiam penetret per cuncta meabilis Aer.* These Reasons duely perpended, though it seems a Paradox, yet is it no light and vain Conjecture, that the Foetus doth respire in the womb, at least gently and placidly, and in proportion to the pulsation of his heart; which being calmly and softly moved (as are the hearts of Dormice and other Animals, that sleep all the winter) hath but a small necessity of Aer. However, reflecting upon the singular fabrique of the vessels in the heart of an Infant unborn, which all Anatomists conceive made by the providence of Nature, only in defect of Respiration; as we proposed it a *Problem*, so we leave it to the consideration of wiser heads.

16. The Motion of the *Brain* dependent, not upon Respiration but upon the *Pulsation of the Arteries.*

Here also we may opportunely touch upon the *Motion of the Brain*, which consisting (as that of the Lungs) of a Diastole and Systole, many

many have referred to the Inspiration and Expiration of Aer; as if the Brain were dilated for the admission of Aer, and contracted again for the exclusion of it. Whereas, indeed, this Motion doth nor belong (1) to the *substance of the Brain*; for, that being very soft, tender, and delicate, seems uncapable of any such dilatation and compression. Nor (2) to the *Membranes* investing the braine; because, as *Riolan* observed in the head of a Sheep, the diastole and systole of the brain hath been continued long, after part of the skull and Membrans also were cut off. But only to the *Arteries*, (1) because the Motion of the brain is exactly coincident and concordant with that of the Arteries, as may be discerned by the touch, in the heads of Infants new born, and in large wounds of the skull. (2) Because the chief Pulsation is in the upper part of the *Dura Mater*, which is conspersed with store of Arteries ascending from the *Plexus Arteriosus Mirabilis*, and disseminating themselves upon it. (3) Because *Waleus* observed, that in some persons, who fell into extrem agonies, and swooning fits, upon great fractures of the skull, the motion of the brain ceased, and was begun again, as their Pulses recovered. (4) Of what *use* should the inspired Aer be to the Brain? For *Refrigeration*, it cannot be; the temper of the brain being such, as seems to require rather Calefaction. And, as for the *Generation of Animal spirits*; *Dr. Harvey* hath upon good reasons made it doubtfull, whether there be any such or not:

and

and if there be, certainly they consist only of the purest and most subtile parts of the blood, and not of Aer, by the admission of which they must needs become more crass and unfit for those noble uses, to which they are consigned. And, therefore, *Riolan* said well; *Nec spiritibus permiscetur Aer in Cerebro, quia debent esse subtilissimi; alioquin permixtione aeris crassiores evadeyent, nec tam celeriter in universum corpus excurrerent per nervos.*

Encheirid. Anatom. lib. 4. c. 2.

Nor must we here omit to touch upon the *Secundary* Uses of Respiration, which are Manifold. For, it serveth (1) to the *creation of the Voice* (whether Articulate, as in Man; or Inarticulate, as in Bruits) the Lungs exploding the inspired aer, through the Aspera Arteria, with such impetuosity and swiftness, as that its frequent and strong Elisions in the head of the Larynx, the throat and other parts of the mouth, cause it to yeeld a found. (2) to the *Distribution of the Chyle* both out of the stomach and guts, through the venæ Lacteæ, into the grand Receptacle, and out of that Receptacle into the ductus Chyliferi: the middle part of the Diaphragme, in Inspiration, depressing the stomach and guts; and its two long carneous productions lying so immediately under the Receptacle, as that they cannot be distended, but they must at the same time also distend it, and so express the Chyle out of it. (3) to *the Exclusion of the Excrements* both of the Guts and Bladder; the depression of the Diaphragme together with the compression of the Abdomen,

17. The *Secondary* Uses of Respiration.

streightning and urging those parts, (4) to *Smelling*; the odours being brought into the Nostrills together with the inspired Aer. (5) to *Coughing*, *Sternutation*, *Exscreation*, and *Emunction* of the Nose; while the breath is driven forth with violence and suddainly. And (6) to *assist the whole body in any strong and vehement motion*; while, either the Inspiration being made gentle and small, and the breath kept in, the Muscles of the Abdomen and other parts are consequently stretched; and so we are the better enabled to lift up things of great weight, or to repell things making resistence by force of impulsion or otherwise: or, after a great inspiration, a vehement and suddain exspiration succeeds, and then the Muscles are extended together with the like force, so as the Armes and Legs are strengthned either in giving a blow, or leaping, or other the like efforts, to which main force is required. And thus much of *Respiration*.

OF

OF THE LYMPHEDUCTS.

Exercitation the Ninth.

Of the Lymphedufts.

A Mong the new Discoveries made in the Microcosme, by the Anatomists of this our age (wherein Nature seems to have rewarded the sweat and industry of her ingenious Votaries, with the knowledge of sundry Secrets, which she wholly concealed from our Predecessors) *These vessels* are not the least: nor can you have a compleat History of the Oeconomy of Nature in an Animal, without assuming both them, and the Liquor they contain, into particular consideration.

Article 1. The Lymphedufts, a new and excellent Invention.

To whom the Honour of their *Invention* doth belong, is yet in dispute. For, though that most diligent and perspicacious Anatomist, *Thom: Bartholinus*, be the man, who first wrote of them; and He challengeth the glory of their discovery wholly to Himself: yet is it well known, that our Country man, *Dr. Jolive* (a person of singular dexterity, and admirable felicity, in dissection of all sorts of Animals, as well living, as dead) had discovered and

2. To whom the honour of their Discovery is to be ascribed.

and mentioned them to many Physicians of best note, and among the rest particularly to that eminent Master in Anatomy, *Dr. Glisson* (who makes grateful acknowledgment thereof, in his most elaborate and judicious Book, *de Anatom. Hepatis*) more than a whole year, before *Bartholine* wrote his Treatise particularly concerning them. So that it being improbable *Dr. Jolive* should borrow the notice of these Water-vessels from *Bartholine*, and as improbable, on the otherside, that *Bartholine* should receive the first Hint of them from *Dr. Jolive*: it seems equitable the Honour of this invention should be divided betwixt Them, as Men, whom good Fortune, conspiring with their industry, might haply bring to the investigation of the same thing, neer about the same time; notwithstanding they were divided by so large a distance, as is betwixt England and Denmark, and held no commerce each vvith other by Letters, or othervvise. But vvhoever vvas the Inventor, certain it is the Invention it self is of admirable advantage to the Republique of Physick: and therefore, vve shall briefly recite the summe of vvhat hath been vvritten concerning their *Description*, their *Origination*, their *Insertion*, and their *Uses*.

3. Their Description.

The *Lymphedukts* are certain Whitish Vessels, in many places of the body running along close upon the veins, and sometimes embracing them in various circles, as the surcles of the vine tvvine about the branches of an Elm,

consisting

consisting of a very thin and transparent *membranous substance*, not much unlike a spiders web; in *Figure* for the most part roundish; in *magnitude* seldome exceeding a Ravens quill; furnished with sundry tender valves; and containing a *Liquor* thin, insipid, and for the most part whitish, but sometimes tinged either with blood, or with a yellowish colour.

Of these are *two sorts*; some accompanying the larger veins in the Limbs, or exterior parts; and others associating themselves with the veins in the Abdomen, especially with the *Vena Portæ*, the *Iliacal* veins, those disseminated upon the *Testicles* in both sexes, and upon the bottome of the *womb* in Females. 4. Differences.

Accordingly, their *Origine* is twofold; for those in the Abdomen arise either from the Liver, or from the Bladder of the Gall, or *Capsula communis*: and those in the Limbs, have their original from those parts; but, whether from the capillary veins, or from the capillary Arteries, or from the extremities of the Nerves, is not yet determined. Onely we have the late observations of *Olaus Rudbeck* (Physician to Queen *Christina* of *Sweden*) to attest, that they arise almost from all parts; he having found them also in the Lungs, Mediastinum, Heart, suspensory ligament of the Liver, stomach, spleen, loyns and sundry other parts. 5. Origination.

Their *Insertion* likewise is twofold. For, those in the Abdomen are all terminated in the 6. Insertion.

the grand Receptacle of the Chyle, into which as into a cistern, they infuse that thin liquor, which they carry in their pipes; that so the same being there commixed with the Chyle, may be conveyed along with it, through the *Lacteæ Thoraticæ*, into the *subclavian vein*. And those above the *Diaphragme*, or such as arise from the Limbs, are inserted into the *External jugular* Veins, into which they disembogue their several rivulets. Wherefore they have no common Trunck, but (like several Springs of water) rising up here and there from divers parts, they all tend into two large channels, *viz.* the Receptacle of the Chyle, and the *Vena Axillaris*, that their streams may all meet in the common Ocean of the Heart.

7. Situation and Progress.

As for their *Situation* and *Progress*, it is thus. In the Armes, they creep up by the side of the *Vena Brachialis*, to which they are firmely connected, and so ascend together with it to the *Vena Axillaris*, into which they open themselves with a small inlet, or Orifice, that is guarded with a valve, set there by Nature, to prevent the reflux of the liquor out of the Axillary vein. And, from the *Thighs*, many in like manner climb up in the company of the Crural and Iliacal veins, which they encircle in some places more closely, in others more laxely; and in this manner they mount up to the Mesentery, where together with the small branches of the *Vena Portæ*, they are terminated. Again, those issuing from the *Liver*, or *Bladder of the Gall*, do also descend in com-

pany

pany of the *Vena Portæ*, to the middle Glandule of the Mesentery, and are therein terminated. But, if with a more curious eye you trace these proceeding from the Liver, up to their very original; you may perceive them to enter the *Capsula Communis*, of the *Vena Portæ*; and therein so to lose themselves, as that you cannot discern their progress from thence; yet it is probable, that being included in the same *Capsula Communis*, they follow the distribution of the same, and never stray from it into the *Parenchyma* of the Liver; because, if they did, how comes it, that they are no where to be found in the parenchyma, no not in that part of it, where the *Capsula Communis* is?

Concerning the *Liquor* they contain, there are two Difficulties, *viz.* (1) *Whence they receive it?* (2) *Why they return it into the Receptacle of the Chyle, and into the Heart?*

The *Former* is solved, by saying, that the *liquor is derived partly from the Arteries, partly from the Nerves.* That the *Arteries* have some share in bringing that mild and thin Liquor into the Lympheducts, may be argued thus. The blood, being by the Vital Heat and Motion, agitated in the Arteries, doth necessarily diffuse abundance of Vapours into those parts, into which it is immitted; and this so much the more, because those vapours are repressed and kept in, by the thickness of the coats of the greater Arteries, untill they are driven into the smaller arteries, through whose thinner coats they more easily trans-

8. Liquor deduced partly from the Arteries, and

pire. And those vapours thus dispersed, are for the most part retained and re-collected by the Fibrous and Membranous parts, and by that means condensed into a Liquor, which makes one part of that Humor which the Lymphducts carry away. For, we are not to conceive, that that Liquor was preexistent in the Arteries, under the same form it afterward obtains in the Lymphducts; and that being protruded together with the blood out of the Arteries into the substance of the parts, it is in those parts separated from the blood, by any kind of Percolation, as the Urine is in the Kidneys: because there are in all parts Veins answering to the Arteries, and those ample enough to export whatever liquor is by them imported: nor can any reason be given, why that watery humor should be at all separated from the blood; seeing it is no Excrement of the blood, though it may be accounted an Excrement of the parts, from which immediately it is immitted into the Lymphducts. No Excrement of the blood, because it is again brought into the blood; and Nature useth not to lose her labour, or to separate things each from other, on purpose to mixe them again afterward.

9. Partly from the Nerves.

Secondly, that the *Nerves* also contribute some part of this Liquor to the Lymphducts, may be inferred from hence; (1) that whatsoever Liquor ariseth from vapours condensed, is perfectly pure, thin, and transparent: but this liquor is not so, and therefore it is necessary

ſary ſome other Humor ſhould be admixt to it, which gives it a greater thickneſs, than a ſimple diſtilled water uſually hath. For, this whole liquor is more denſe, and leſs diaphanous, and ſometimes white like milk, ſometimes tincted with yellow, and ſometimes with blood, like water wherein raw Fleſh hath been waſhed. (2) It is an opinion highly agreeable vvith Reaſon, that the thicker part of the Liquor found in theſe Water-conduits, is the Vehicle of the *Succus Nutritius*, vvhich being diſpenſed from the brain and ſpinal Marrovv, to all parts for their nouriſhment, by the Nerves, is aſſimilated into their ſubſtance, leaving its thinner part (vvhich before ſerved to promote and facilitate its diſtribution through the ſlender paſſages of the Nerves) to be infuſed into the Lymphe-ducts, vvhich return it into the blood, for a *double uſe*, viz.

First, to prevent the *Coagulation* of the blood, to vvhich othervviſe it vvould be ſtrongly inclined. Secondly, to promote the *Mication* of the blood; for this thin liquor, being formerly advanced to the ſtate of Volatility, or exhalation: it is eaſily united to the Vital blood, and doth as eaſily advance the mication of it. 10. Uſes of that Liquor.

But, vvhat vve here ſay, of the derivation of one part of this Liquor from the Nerves, vvill be more illuſtrated by vvhat follovvs, concerning the diſpenſation of the nouriſhment by the Nerves.

OF THE DISTRIBUTION OF THE NOURISHMENT THROUGH THE NERVES.

Exercitation the Tenth.

Of the Distribution of the Nourishment through the Nervs.

Article 1. That the Nervs are the vessells carrying the Nutritive juyce to the parts; argued

IN one of our precedent Discourses (as you may please to remember) we denied the Blood to be the Adequate Aliment of the Nervous, Fibrous, and Membranous parts of the body; and transferred that noble office upon a certain milder and sweeter juice, congenerous to that spermatical Matter, of which those parts are first made up: Lest therefore, we should defraud your curiosity of such further satisfaction, as this new and paradoxicall (yet most reasonable) opinion requires; we must no longer omit to explain (at least according to what light the excellent *Dr. Glisson* hath given, in so obscure an Argument) *From whence, and by what vessells, the Nutritive juice is distributed to all parts of the body.*

The *Thesis* is, that the proper and adequate Nutriment of the Parts, is derived to them from the Brain and Spinal Marrow, by the Nervs: and the *Reasons* asserting it, are these.

(1) In

(1) In the *Palsy*, it is observed, that the parts resolved do at first appear somewhat tumid or swolne, by reason of the laxity of their Fibres, and the easie afflux of blood unto them. And yet it is manifest, that swelling doth not arise from the true and genuine Nourishment of those parts; because afterward they by little and little pine away, to extream leanness, notwithstanding the blood floweth as freely and plentifully to them then, as before. A pregnant argument, that the vessells, by which they ought to be supplied with nourishment, are obstructed; which vessels, certainly, can be no other but the Nervs, because both Arteries and veins are wholly exempt from any impeachment, in this Disease; and the Nervs alone fail of performing their office, as they ought.

2. from the Atrophy, or decay of nutrition in parts affected with the Palsy, and whose Nervs have been wounded.

This may be confirmed by an observation of our owne. A certain woman having a Nerv pricked by an unskilfull Chirurgeon, as he was letting her blood in the right arme, was at first surprised with Convulsions of that Arme; and those ceasing, there ensued so great an Atrophy of that member, as nothing now (for the woman is yet living) remains of it but skin and bones: which extream extenuation, doubtless, is to be referred to the want of passage for the Succus Nutritius, through the principal Nerv in the Arme; no such accident (but an Aneurisme) usually following upon the incision of an Artery.

3. from the beneficial use of *Cephalique* Emplastres in Consumptions from ulcerated Lungs.

(2) In a *Phthisis*, or Consumption from ulcerated Lungs, *Cephalique Emplastres* (though composed

composed of heating and drying ingredients, and in that respect seeming very incompetent for such a Disease) are found by experience to be very beneficial to the sick; and that, not only because they stop the defluxion of humors from the head upon the Lungs: but also (and chiefly) because they warme and corroborate the Brain and Nervs, and so promote the Nutrition of the Parts. Which effect cannot be expected from their Heat and Drinesſ, but from some comfortable influence transmitted to the Nervs, by which they are strengthned and made fit for the performance of their office, *viz.* the conveying the nourishment from the brain to the parts.

4. From the *Fatness* of men endowed with large, open, spongy and moist nerves

(3) As those persons are inclined to Leanness, who abound with blood; so are those inclined to grow *Fat*, who *have large, moist, open, and spongy Nervs*; for, such Nervs afford much Aliment, and distribute it easily.

5. From the *roscid humor* exstilling from wounds of the joynts and sinewes.

(4) It is commonly observed, that from wounds of the joynts and Nervs, there distills a certain roscid Humor, not much unlike the white of an Egg; which being not likely to come from either the Arteries or veins, in respect they carry nothing but blood; why may we not believe it to drop out of the Nervs? Also in such wounds, in issues, in hollow Teeth, &c. there grow up frequently certain fleshy Excrescences, or Proud Flesh; which being exceeding sensible, and subject to acute pain upon the least touch, cannot but have a very neer relation to the Nervs: and blood

certainly

certainly is very unapt to produce such Excrescences, to the Generation of which some matter analogous to the sperme is necessarily required.

(5) The same may be said also of Wens and Scrophulous Tumors, which seem to derive their Seminal Matter from the dew or Gleet of the Nerves, and not from any humor effused out of the Arteries or veins; blood being a liquor partaking of too much Asperity and Acrimony, to be the material Principle of such Tumors: besides, we have the testimony of our sense; that the rudiments of such Tumors, are like Eggs included in a membranous filme, which contains a humor resembling the white of an Egg, but nothing like blood. Moreover, these Tumors frequently tend to some kind of Formation, though but an imperfect one; producing sometimes a mass or lump of Flesh, sometimes a Worme, or other such Monster; which is a strong Argument, that their primitive Matter is not blood, but a certain juyce much milder and sweeter, and brought to the parts in which they are generated, by the Nervs.

6. From the *Material Principle* of *Wens* and *Scrophulous Tumors.*

(6) This Opinion is further confirmed by the Matter of the Seed, and the Manner of its preparation in the Testicles. For, the Seed seems to be generated, not of the blood (as hath been vulgarly believed) but of a matter much sweeter and more generous, brought into the Seminary vessells, from the brain, by the Nervs; forasmuch as the Nervs are both more

7. From the *Matter* of the seed, and the *Manner of its preparation* in the Testicles.

more copiously and more deeply disseminated into the parenchyma of the Testicles, than either the Arteries, or the veins; which is the reason, why their inward substance is white, not red. Again, their proper Coat appears to be nothing else, but a certain expansion of the Nervs inserted into them; from which Coat many small Nervs are on all parts derived to the middle of the Testicles, where meeting together, they make the long Nervous vessell, that manifestly exonerateth it self into the Chanel of the Epididymis, as may be plainly seen in the stones of a Horse, Bull, Boar, or other large Animal. As for the veins of the Testicles, they serve only to export the blood imported by the Arteries: and the Arteries themselves, though they variously diffuse themselves round about the Testicles; and accompanying the Nervs, tend in divers places from the inward coat, to the *Ductus Seminalis* (situate in the very middle of the Testicle) and are connected thereunto; yet they rarely disperse any branches, untill, reflecting from that chanel, they have begun their progresse back again toward the Circumference of the Testicle. But, there they send out some surcles to the outside of the Testicle; to the end that, those capillary veins, opening themselves into the substance of the Testicle, may the more easily receive the blood effused out of the Arteries, and so carry it off again. Because, that blood, if left there, would soon obstruct the parenchyma of the Testicles, and

disturb

disturb the præparation of the seed. Yet these Arteries do where insinuate themselves into the Nervous, or Seminal Chanel, or infuse the least drop of blood into them: So that it is more then probable, they serve rather for the vivification of the Testicles, by bringing the vital blood and spirits into them, than for the importation of the Seminal Matter. Now, the Nervs implanted in the Testicles, cannot be in order to their Motion, because they have none that is voluntary; nor is there any need of them, as to sensation: and therefore it is more credible, that their Use is only to bring in some certain Liquor, for the making of seed. Furthermore, the Testicles are furnished with many Lympheducts, which could be of little Use unto them, unless there were some other vessells present also, by which that generous Liquor is brought in, whose thinner and superfluous part those Lympheducts are framed to export. Add to this, that the seed is a liquor much more noble and Ambrosiack, than the blood; as is evident even from hence, that a small expence of seed doth more exhaust the spirits, than the losse of twenty times so much blood. Which doubtless, is the reason, why Heavinesss and dejection of spirit, do alwayes ensue after the delights of Venus; and it hath been observed, that in men excessively addicted to women, the Brain it self is not only much debilitated, but made also lax, thin, and watery. The Gout likewise is generally an Attendant of immoderate venery; because the joynts

and nervous parts being much debilitated, and the roscid and Unctuous Liquor of the Nervs, deprived of its milder and sweeter part; the Succus Nutritius becomes too thin and sharp, and so is more expeditely discharged upon the joynts.

8. from the *Glutinous matter* issuing from the ends of *broken bones*, and cementing them together again.

(7) From the Extremities of broken Bones, there sweats forth a certain Glutinous substance, very beneficial toward the uniting and cementing them together again: which liquor cannot proceed from the Arteries, whose office is only to convey the blood (a liquor vastly different from this Glew): and since besides them, and the Nervs, there is no vessell yet found out, that carries any humor from the Center to the circumference of the body; it is very reasonable to conceive, that this Glew is derived from the Nervs.

(8) The *white* of Eggs is brought into the womb of the Hen, by the Nervs. For, it hath no resemblance at all to blood; nor can it be generated of blood, unless by way of separation, but there can be no separation made in that part, in respect it is wholly destitute of any *Parenchyma*, which is absolutely necessary to the separation of any two Humors one from the other. Whereas the secretion of the *Succus Nutritius* brought by the Nervs, seems to want no *parenchyma*, and may be effected in parts the most bloodless. And that such a Secretion of the *Succus Nutritius* is made in the womb, is manifest from the great number of *Lympheducts* returning from thence, which Nature had never

ner ordained in that place, unless it were to export the thinner and superfluous part of the *Succus Nutritius* brought to the womb by the Nerves. So that the very Lymphedücts seem to teach us, that the *Succus Nutritius* is derived into the womb by the Nerves; and that the watery part thereof being protruded into the Lymphedücts, the more unctuous and profitable is transmitted into the cavity of the womb, there to make the *white* of the Egg.

9. From the *Unequal* nourishment of some part, in that *Rickets*.

(1) In the *Rickets* there is generally observed an *Inequality of Nutrition*, which (according to the most of probability) proceeds from the less aptitude of some Nerves, to carry the nourishment, than of others. For, that Disease seems to be seated originally and principally in the Spinal Marrow without the skull, and in the Nerves thence propagated: and therefore those Nerves must be more weak, languid, and unfit to transmit the Succus Nutritius, than such as arise from the Brain, or Marrow within the skull. And hence is it, doubtless, that the Head, Face, and *Viscera* of the *Abdomen* (all which derive their Nerves from the Marrow within the skull) grow excessively great: while the Armes and Leggs become lean, flaccid, and enervate, as being supplyed with nourishment by Nerves, issuing from the Spinal Marrow without the skull. Moreover, because it sometimes happens, that some one particular branch of this or that Nerve, is more debilitated, than the rest;

thence it comes, that one part of a Limb is better supplyed with nourishment, than the other; and so, by that unequal Nutrition of its parts, the whole member growes crooked. And these are (among many others) the chief Arguments, that have perswaded us, that the *Nourishment of the parts is brought to them by the Nerves.*

10. *Three grand Difficulties, troubling this opinion.*

Among the *Difficulties* encumbering this opinion, there are 3 that especially deserve consideration, *viz.*

(1) *That in the Nerves no passages or cavities can be discerned, through which the Succus Nutritius may be convey'd.*

(2) *That in the dissection of Animals alive, and the application of a ligature to any Nerve, no swelling can be observed to arise on either side the Ligature: and upon cutting off a Nerve, very little or none at all of this supposed Liquor can be discerned to distill from either end; contrary to what happeneth in the binding and cutting off any other vessell.*

(3). *No such Liquor hath yet been found in the Nerves of bodies dissected.*

And yet these Difficulties are not weighty enough to counterbalance the Reasons formerly alleadged; for asmuch as they may be easily solved, by *Answering* to the

11. *Solution of the First, asserting the possibility of the flux of the Nutritive*

First; that though no manifest hollowness be discernable in the Nerves (such as is in Arteries and Veins) yet is it not impossible, but the supposed Succus Nutritius may distill gently through them. For, it is well known

by

by the experiment of laying the Spinal Marrow, or any Nerve in water; that the Nerves are made up of many small Fibrous Filaments, or threads cohering together, with a soft medullary substance betwixt them: much like the Indian Canes, which, though in the cortex so hard and compact, as to yield fire upon percussion with a Tobacco-pipe, and as solid within as many sorts of wood; being yet composed of many small and long Filaments, with small perforations betwixt them, are pervious from one end to the other, so as a man may without much difficulty blow his spittle quite through them. Likewise, in the leaves of plants, there shoots up a certain small Nervous rib, arising from the Foot-stalke, by which they are fastned to the branch; and without which nothing of nourishment can be brought to them. This little rib running up in the middle, sends forth various lesser surcles or threads equally to all parts of the leaf, so as the whole is thereby equally nourished. And yet, if you cut off this rib, or any one branch of it, you shall discover none the smallest cavity or hollowness therein, nor any drop of juice issuing out of it, unless in the Sowthistle, Esula, Celendine, and some few other plants, which emit either a milky, or a yellowish juice, which certainly is their nourishment. And though other plants yield not, upon cutting of their leaves, the like juice, yet most certain it is, they are nourished with some kind of juice or other, derived to them by their Foot-stalks; So that

juice, through the Nervs, notwithstanding no manifest *Hollowness* can be discerned in them.

that we can perceive no such absolute necessity of any manifest cavity in their small ribbs, for the dispensation of their nourishing juice, as this Objection seems to import; especially when we consider, that the Motion of the Succus Nutritius in those slender Filaments or threads, is very gentle, slow, and insensible; not rapid, or Violent, as the motion of the blood in the Arteries and Veins of Animals. Now, since our sense is witnesse, that liquor may be transmitted through a Fire-cane though sufficiently solid and compact; and our Reason assureth, that the Nutritive juice of Plants is distributed to all parts of the leaves, through the Foot-stalk, and little Rib running up in the middle of each leafe, though we can discern no manifest passages, or channels, through which it flowes: Why may not the nourishment of Animals be, in like manner, dispensed to the parts, through the Nerves, notwithstanding they appear destitute of any conspicuous hollowness? But yet some Nerves there are not so impervious, but they admit a small style or probe into them; in which number are the Optique and Odoratory Nerves: and though the rest have not the like visible hollowness, yet reflecting upon this, that all the Nerves are framed for the performance of some one Common Office, it is not unreasonable to conceive, that all of them are perforated more or less, so as to be capable of conveying the *Succus Nutritius*. This may be in good part inferred even from hence, that the

Apoplexy

Apoplexy often ends in a Palsy; in which case all Physicians grant, that the Humor oppressing and obstructing the Brain, is discharged thence upon the Spinal Marrow, and Nerves affected; which could not be, unless the Nerves were capable of being obstructed by the Humor protruded or impelled into them.

You will reply, perhaps; *that they are capable, indeed, of the influx of Animal Spirits, unless their originals chance to be obstructed, as in the case of the Palsey: but, as for any Liquor, or Humor (of far lesse subtility, than those Spirits) it is impossible they should admit it into them.* And we may return, that the supposed Animal Spirits (nor, in truth, the Vital ones) are any where to be found in the whole body, pure or sincere, and without mixtures; and therefore, if the Nerves were framed for the reception of any matter pure and distinct from all others, certainly that matter must be of a grosser substance, than simple and abstracted Spirits.

Furthermore, that there are small Channels in the Nerves, may be perceived by their Compression in our limbs, as when we have long sate upon a hard seat, or otherwise streightned our sinews; for, in that case, we feel a certain *Stupor*, or *Numbness* (the vulgar say, their limbs are *asleep*) in that part, to which the compressed Nerves are prolonged: a certain document, that the free passage of some matter through them, is at that time intercepted; and the compression being removed, there instantly

instantly ensues a kind of troublesome Tingling of Pricking, as if the part were pierced with needls; and this only because what was arrested and intercepted there, begins again its former liberty of motion. These things duely weighed, we may lawfully conclude; that it is not sufficiently evinced, that the Nerves are impenetrable by the *Succus Nutritius*; only because they have no manifest cavity.

12. *Solution* of the *Second*, yeelding the reason, why no *swelling* ariseth in a Nerv, when bound with a Ligature, in a living Animal.

Second; that in the dissection of an Animal alive, it generally happens that by reason of the extream striving and agony of the poor tortured Creature, before the dissector can come, either to apply a ligature unto, or to cut a Nerve; all the Liquor contained therein is squeezed forth into the part, wherein the Nerve is terminated; so that no wonder, if there appears neither swelling on either side of the ligature, nor any exstillation of liquor from the ends of the Nerve cut off. And this Violent streyning of the Nerves in dying Animals, and the squeezing of the Liquor contained in them, into the parts to which they are inserted; seems to be the Cause, why that *Lymphedust*, which corresponds to the Nerve bound or cut, is found more full and distended, than ordinary, as hath been of late frequently observed. And yet we have been assured by judicious and credible persons, that they have seen no small quantity of the Nutritive juice exstilling out of the *Nervous Chord of the Thigh* in a man; and pressed some of it out

out of the *Axillary Chord*, in Dogs.

Third, as to the *Second*; adding withall, that (besides what hath been said, of the cutting of the Nervous Fibres in divers plants, without effusion of the least drop of their Alimentary juice) the Motion of the Succus Nutritius through the Nervs, is neither Continual, nor impetuous, but by intervalls, and gentle, so as not to be perceived: and that all of it being forced into the parts, by reason of the strong Contention or streyning of the Nervs, in the very agony of death; and all impulsion of humors in the body, ceasing after death; it cannot seem strange, that none of the Succus Nutritius can be found in the Nervs of bodies dissected after death.

13. *Solution* of the *Third*, shewing the reason, why the *Succus Nutritius* is not found in the nerves of *dead* bodies dissected.

These Grand Objections thus solved, it remains that we enquire; (1) *What is the Principium Elaborationis of the Succus Nutritius, or where it is prepared*: (2) *what is the Principium Dispensationis of it, or whence it is immediately infused into the Nervs, which convey it to the parts*: (3) *By what vessels it is imported into that principium Dispensationis*: (4) *what kind of Motion it hath in the distributing Nervs*: and (5) *what is the Cause of that Motion.*

14. What is the *Principium Elaborationis* of the Nutritive juice; *viz.* the *Glandules* of the *Mesentery*, of the *Loins*, and the *Thymus*.

Concerning the *First*, *viz.* the Parts wherein the *Succus Nutritius* is prepared, immediately before it is imbibed by the Nervs; there is good reason for us to believe, that this work is effected in the *Glandules of the Mesentery*, in the *Three Glandules of the Loins*, and in the *Thymus*, or Glandule in the Thorax. Which opinion

that we may the better explain, it is requisite we make a short Digression concerning the *Differences* and *Uses* of the *Glandules*, according to the observations, and consequent Conjectures of *Dr. Glisson*, and *Dr. Wharton*.

Of the *Glandules* in the body, there seem to be 3 sorts (respectively to the Nervs) whereof some are inservient to *Excretion*, some to *Reduction*, and some to *Nutrition*. For, though it be most true, that the Common office of all the Glandules, is *Secernere*, to make some separation; yet is it no less true, that that separation is various, as tending to Excretion in some, in others to Reduction, and in others to Nutrition; and the *Matter* it self, which is separated by those divers wayes of Secretion, being likewise various, the first sort being a meer Excrement; the Second, an Excrement only in relation to some parts, but profitable in relation to others, and therefore not to be excluded, but retained; and the last, the true *Succus Nutritius*.

Under the *First* Classis of those Glandules, are comprehended the *Testicles*, the *Prostates*, the *Vesiculæ Seminales*, the *Paps* in women, and the *Glandulæ Maxillares*, or spitting Glandules under the Tongue: all which are furnished with a peculiar *Excretory* vessell, by which they discharge and avoid some superfluous matter brought into them by the Nervs.

To the *Second* (inservient to the secretion of a humor, and the reduction of it into the veins afterward) belong the *Glandulæ Renales*, or Deputy

puty Kidneys, the Glandules *neer the Fundament*, those adjacent to the *Oesophagus*, the *Parotides*, *Axillary*, *Inguinal*, &c. Glandules. All which receive from the Nervs, a certain humor more rough and acrimonious (and approaching to the nature of the blood) than is agreeable with the Succus Nutritius; and therefore the Nervs, by the help of these Glandules discharge themselves of it, and retain only the more sweet, mild and profitable juice. But, because the Humor, thus rejected by the Nervs, hath some affinity to the blood, and in respect of its thinness is commodious for the more easie transportation of the blood, through the narrow meanders of the veins: therefore is it not excluded out of the body, as an absolute Excrement, but imbibed by the Glandules adjacent to the veins, and by them imported into the veins. Which seems to be the most satisfactory reason, that hath hitherto been given, why such Glandules are placed, for the most part, neer to the greater Divisions of the Nervs and veins; *viz.* that they may the more conveniently receive the humor effused out of the Nervs, and deliver it again into the veins.

And to the *Last* (inservient to the Præparation of the true Succus Nutritius) belong the Glandules of the *Mesentery*; the 3 Glandules of the *Loins*, and the *Thymus*, or single Glandule in the Chest, neer the Ductus Lacteus Thoracicus, and in Brutes called the Sweet-bread. For, (11) as to the *Glandules of the Mesentery*; Anatome assureth us, that a great multitude

of the *Venæ Lacteæ* tend unto them, and are in them distributed into surcles extreamly small; and that other small branches (or rather roots of milky veins take their beginning in the same Glandules, and progressing from thence, make a second sort or race of *venæ lacteæ*, as we have more particularly declared before, *in the 2d Art. of the 3d Exercit.* Now, to what end hath Nature made these two kinds of Venæ Lacteæ, one sort to import the Chyle into these Glands, and the other to export it? unless it be, that the Chyle should either suffer some Alteration, or be separated from some Humor, in these Glandules? Alteration it suffers none; because it is carried off again in the same forme, as it was brought in. And, therefore, it remains probable, that it is brought into the Glandules, only that it might be separated from some parts less agreeable with the nature of pure nourishment. Now, what should the Humor be, that is thus to be separated? An absolute Excrement it cannot be, because these Glandules have no peculiar Excretory vessells, as all parts inservient to any Excretion have. Nor is it like that matter, which is reduced into the veins, by the Reductory Glandules: for, if it were such, it would need no such separation at all, the rest of the Chyle soon after flowing into the subclavian vein, and it being easie for Nature to have contrived, that the chyle brought into these Glandules, might have accompanied the rest in that journey, without any intermediate Secretion. This

considered,

considered, it is reasonable to conceive, that the Liquor separated from the Chyle, in these Glandules, doth not belong either to the First, or Second sort of Matter (*viz.* the absolute Excrement, and the Excrement Relative) formerly mentioned; but is the true *Succus Nutritius.* Which being granted, it is not difficult to explore, by what vessells this *Succus Nutritius* is from thence carried away. For, since it cannot be thence exported by any peculiar vessells, nor by veins; it must be by the Nervs. (2) As for the Three *Glandulæ Lumbares*; it is probable, They also are official to the Nervs, in the same way; and that for two important Reasons. *First*, because they are furnished with Venæ Lacteæ of both sorts, some tending to them, and others propagated from them, and exonerating themselves into the Common Receptacle: in all points like the Glandules of the Mesentery. *Secondly*, because in such Animals, as have the Glandules of the Mesentery very large, these *Glandulæ Lumbares* are either very small, or wholly deficient; and in men, in whom the Glandules of the Mesentery are but small, the Lumbares are great: an undeniable argument, that the same office is common to both sorts, and that the exility of those is supplied by the amplitude of these. And (3) the *Thymus* also seems to be a *Nutritious* Glandule. For, in Infants, and other Animals new born (at which time, they grow much, and so require the more abundant nourishment) the magnitude of this Glandule doth

doth exceed that of any other in the whole body: but, in old men (who daily go down the hill of life, and so have less need of nourishment in such abundance) it dwindle's away to a smallness many times scarce discernable. Again, this Glandule hath no Excretory vessell, nor (like other greater Reducing Glandules) any hollowness within; and therefore, we may well list it in the number of Nutritious Glandules. Add also, that it is white, soft, and very sweet, and in substance resembling the Glandules of the Paps: so that in probability, as the paps serve to prepare nourishment for the infant, *ab extra*; the Thymus supplieth him with nourishment, *ab intra*; receiving the same, perhaps out of the *Ductus Lacteus* in the Thorax, which in its approach to the Thymus, is usually divided into two streams or rivulets. And these are the reasons, upon which we conclude, that the Nerves take in some of the *Succus Nutritius*, out of each of these Glandules mentioned, whose use seems to be, to separate the same from the less Alimentary parts of the Chyle.

15. What is the *Principium Dispensationis* of the same; *viz.* the *Brain* and *Spinal Marrow*.

Concerning the *Second* thing enquired, *viz.* what is *the Principium Dispensationis*, whence the Succus Nutritius is immediately immitted into the Nerves, which convey it to the parts requiring nourishment? We say, that the *Brain* and *Spinal Marrow* seem to have the best title to that office, of all other parts, in respect that all the Nerves desuming their original from, and having their extremities or roots

immediately

immediately fastned unto either the Brain, or Spinal Marrow, the Nutritive juice may commodiously and easily from thence distill down upon all parts of the body; according to their particular conditions and necessities.

Concerning the *Third*; viz. *By what vessels the same Nutritive Liquor is brought into the brain and Spinal Marrow?* We say, By the *Nerves*, and particularly those of the *sixth Conjugation*: For, this pair of Nerves, though they appear less than all others, at their first rising from the Brain; do yet hold a commerce with all other nerves of the whole body, and are immediately derived to more parts, than any other pair or Conjugation, which is the reason why Anatomists called them, the *Wandring* or *Dispersed* pair. And the Commerce they maintain with so vast a multitude of other nerves, is founded on a threefold relation or intercourse, *viz. Complication, Consociation*, and *Inoculation*: all which are largely described by *Fallopius*, and after him by our excellent *Dr. Glisson*. Now, if we seriously consider the scope or design of Nature, in all those laborious and curious Connexions of Nerves, we shall find none, wherein our reason may with so much satisfaction acquiesce as in this, that they conduce to the commodious reception of the Nutritive juice and transportation of it to the principle of its Dispensation. For it seems, the Nutritive juice is first imbibed by the small branches of the Nerves of the sixth Conjugation; and those, though very many, being

16. What are the *Vessells importing* the Nutritive juice into the Brain and Spinal Marrow; *viz.* the *Nerves*, and particularly those of the *sixth Conjugation* of the brain.

in observat. Anatomic. de Anatom. Hepatis. p. 436.

being yet too few for the transportation of so large a quantity of that rich Nectar, as is required to the nourishment of the whole body, Nature hath conjoyned with them a vast number of other Nerves, as Auxiliaries in that great work. So that it is not dissentaneous to reason, to conceive, that by these Nerves and their Coadjutors, the *Succus Nutritius* is carried to the brain and Spinal Marrow, thence to be afterward derived to all parts for their sustenance.

17. What is the *Motion* of the same in the Nervs; *viz.* not continual, nor vehement: but *by intervalls*, and *slow* and *gentle*; to the brain, in sleep, and from it to the members, after sleep.

Concerning the *Fourth*, viz. *the Motion of the Succus Nutritius in the Nerves*; though it be a problem of great obscurity, yet doth the light, let in at the postern gate of Conjecture discover thus much, that it is not continual (as that of the blood in the Arteries and veins) but *by intervals*; nor violent, but *slow* and *gentle*; as the defect of any swelling on either side of a Nerve bound about, in a living creature, doth sufficiently manifest. Nor is it unreasonable to conceive, that in a short time after each meal, immediately upon the distribution of the Chyle through the *Venæ Lacteæ*, the Succus Nutritius is imbibed by the Nerves of the sixth Conjugation, and by them carried to the brain and Spinal Marrow. Which perhaps, is the reason, why alwayes, within an hour or two after meat, we perceive a certain dulness in our heads, together with an indisposition to motion, and a propensity to sleep, according to that proverb, When the belly is full, the bones would be at rest: and soon after,

ter, all those vanish again, and we perceive our selves more light, strong, and active than before our refection; because then the nourishment begins to be diffused from the principle of Dispensation, outwards into the limbs and other parts of the body. And with this opinion agrees that observation of *Bartholinus* that the Lymphducts are more plainly discernable about five or six hours after meat, than at other times; as being at that time more filled with the superfluities of the *Succus Nutritius*. Nor is it improbable, that the Brain and Spinal Marrow are chiefly nourished in sleep, and that then the Nutritive Liquor is usually carried to them, relaxing them with its sweet and mild vapours, and so both inducing and prolonging sleep. From whence perhaps it comes, that after long sleeps, we perceive our brains to be oppressed and beclouded with vapours, our senses dull, and the motive-faculty enervated. Besides, in sleep all motions of humors flowing to the parts by the Nerves, seem to be suspended; and yet the Circulation of the blood is certainly at that time more free and quick, than while we wake: So that It cannot be thought the cause of that cessation, but the Nerves onely, which intermit their office of distributing the Succus Nutritius, during sleep. And all this will appear more reasonable, if we reflect upon the flux of humors in the Nerves immediately after sleep. For, then the Brain and Spinal Marrow re-contract themselves, and become

more tense; so that the *Nutritive* liquor is from thence transmitted, partly to the members to be nourished, and partly to the Glandules; as well such as serve for the excretion of its absolute Excrement, as those that serve for the reduction of its relative, *viz.* its acrimonious parts, that are returned into the blood, for the reason formerly mentioned.

18. And what the *Causes* of that Motion, *viz.* the motions of the *Diaphragme*, of the *Brain*, and of the *Nerves* themselves.

And concerning the *Last*, viz. the *Causes* of this Motion of the *Succus Nutritius*; we may be allowed to conceive (at least, untill Time shall have dispelled that Obscurity, which yet surrounds this abstruse Theoreme, and the industry of some more dextrous Anatomist pierced deeper into the mystery of the Nerves; a subject not much lesse inscrutable, than the Nature of the Soul it self, which useth them as her principal instruments: we hope, we may have the liberty to conceive) that the *Succus Nutritius* is not imported to the brain and Spinal Marrow, nor exported from thence to the members, by any Attraction similary or Elective, against which we have formerly alleadged convincing arguments, unnecessary to be here repeated: but, as the blood, and indeed all other humors of the body are moved, by meer *Impulsion*, or *Protrusion*, the immediate Cause of all motions in Nature. And the Agents, in this case impelling, we conceive to be the motions of the *Diaphragme*, of the *Brain*, and of the *Nerves* themselves.

For since the *Depression of the Diaphragme*, is generally admitted to conduce to the distribution

bution of the Chyle out of the stomach, guts, *Venæ Lacteæ*, common Receptacle, and *Ductus Chyliferi*, successively into the subclavian Vein: by alternately compressing all those parts, and so compelling the Liquor contained in them, to flow upward; and indeed to all other Natural motions: why may not the same be thought sufficient also to the Expulsion of the Nutritive juice, both out of the Præparing Glandules, into the Nerves of the Sixth conjugation and their Auxiliaries, and out of them into the brain and Spinal Marrow; their position being such, as renders them no lesse subject to compression, by the descending *Diaphragme*, than the Venæ Lacteæ, common Receptacle, and other *Chyliferous* parts are?

If this seem difficult, we may have recourse to the reason of the ascention of a liquor from the bottome through all parts of a sponge, cloath, or other filamentous substance (as is experimented in the percolation of *Aqua Calcis*, made by a long piece of woollen cloath, whose one end is dipt in the water, and the other hung over the brim of the vessel containing it) which we have professedly explained in the 356 *page of our Physiology*: and seems to be the same with the reason of the ascention of the nutritive juice of all plants from the roots to the top of the branches.

And as for the *Motion of the Brain*; though it may seem to be no other, but what is impressed upon the brain, by the Pulsation of the Arteries (ascending from the *Plexus Arterio-*

riosus mirabilis chiefly to the *Dura Mater*, and copiously disseminating themselves upon it); yet, since it is credible, that the Pulsation of the arteries doth promote the flux of the liquor in the Nerves, in other parts, especially such, where Nerves are either contiguous, or neer enough to *Arteries*, to participate of their impulse: why may not the motion of the Brain also, to which the Nerves are continued, serve to ex-press the liquor out of them, toward the parts wherein they are terminated? Besides, it is most certain that immediately after sleep, the whole Brain, together with the conjoyned net-work of its Nerves, becomes more tense and firme, than in sleep, which seems to render it moist and lax: and since that Tension cannot but in a manner ex-press, or squeez forth, the liquor contained in the original of the Nerves, it is reasonable to conceive, that the motion of the *Succus Nutritius* from the brain to the parts, is to be imputed thereunto; especially it being by us observed, that the diffusion of the nourishment is chiefly soon after we awake and rise from sleep.

And lastly, as for the *Motion of the Nerves* themselves; nothing is more manifest, than that, while the Nerves and Muscles are distended in Voluntary motion, the juice contained in the Nerves must be impelled or ex-pressed to the parts, into which they are inserted; the extension of any nervous body, necessitating the flux of any liquor contained betwixt its filaments, from one extream to the other.

But,

But, this we deliver, not as doctrine, but meer *Conjecture*. Nor should we have adventur'd to deliver it, but that we hope, that as the singular obscurity of the Argument may incite some other more able brain to labour in the same scrutiny; so it may excuse us, if we have not been so happy, as to light upon the knowledge of the true Causes, we sought after; there being among Candid Spirits, not only pardon, but even commendation, due to ingenious Errors; especially in things of Difficulty, and where the discovery of Truth is to be hoped rather from Time and multiplied Observations, than from the single felicity of Witt.

OF

OF VOLUNTARY MOTION,

Exercitation the Eleventh.

Of Voluntary Motion, or the Use of the Muscles.

Article 1. The Inference, and Method of this discourse.

FRom *one* Use of the *Nerves*, viz. the conveying of the nourishment to all parts requiring it; we now transfer our contemplation to the *other*, viz. the *transmission of the Animal Spirits from the Brain* (the principal throne of the Soul, where she judgeth of the good or evill of objects; and from whence she dispenseth her commands) *to the Muscles*, the immediate and proper instruments of Motion Voluntary: and here, for the more perspicuity, we shall take the liberty of permitting our Curiosity to exspatiate it self a while in that delightfull and ample field, the admirable Art of Nature shewn in the *Structure* of those organs, in their *Variety*, and in the *Reason* of their Motions.

2. Requisites to Voluntary motion.

The things required to Voluntary Motion, are (1) the *object* communicated by the sense

to

to the judicatory Faculty, or Soul; (2) the *Soul* perceiving that object, judging it to be good or evill, and accordingly pursuing, or avoiding it; (3) the *Instrumentum Mediatum*, by which the Soul impresseth a motive-Faculty upon the Muscles, and immediately acteth, toward the attainment of her end; and (4) the *Instrumentum Immediatum*, by which immediately the motion intended is executed or effected.

3. That the *Animal Spirits* are the *Mediate* Instruments, by which the Soul moves the Muscles; argued from

Concerning the Exciting Cause, or object; and the primary Agent; there is, nor can be no dispute: it being most evident, that the Soul is the principle of Motion, and that it is excited thereunto by the good or evill appearing in the object. But, concerning the *Instrumentum Mediatum*, or that by which the Soul doth cause the Muscles to move either the whole body, or some member of it, in order to her embracing, or avoiding the object; many, especially of late yeers, have seemed very much to doubt. To satisfie them, therefore, in this particular; we (with all the Ancients) conceive, that the *Animal Spirits* sent from the brain, by the Nerves, into the Muscles, are the Immediate instrument of the Soul, whereby she doth impress an actuall motion upon the Muscles: and to evince the probability of this opinion, we offer these few, yet (in our judgment) weighty *Reasons*.

4. the *Mutation of Figure* both in the Muscle and Member moved:

(1) Voluntary Motion being nothing, but the willing translation of the body of an Animal, or some part of it, out of one place, into another;

nother; it is necessary, the member moved should measure the determinate space betwixt the *Terminus à quo*, and the *terminus ad quem*; and consequently, that the proportion of the member moved, be answerable to the proportion of that intermediate space: now from that necessary proportion, there ariseth a *change* of *Figure*, as well in the member moved, as in the Muscle moving (as we shall ere long demonstrate by *Principles Mathematical*, in explanation and confirmation of the doctrine of our Master *Galen, in* 1. *de motu Musculor. cap.* 8.) but that Mutation of Figure in the external instrument, cannot arise immediately from the Soul it self: which being Immaterial, can of her self produce no such effect: and therefore it must arise from something more proportionate to the immediate energy of the Soul, than either the grossness of the member, or muscles ordained to move it, will admit them to be; which Something can be no other, than the Animal Spirits, whose subtility makes them to approach neerer to the nature of the Soul, and whose sudden influx through the Nerves, into the body of the Muscle, causeth a swelling or distention, and so a contraction thereof, and consequently a change of Figure in the member.

5. the *Quickness* of voluntary motion.

(2) Since every Instrument ought to be accommodate, as well to the nature of the Agent which is to use it, as to the effect to be produced by the use of it; and that Voluntary Motion is performed as it were in an instant and

by

by a most swift and speedy Impulse from the soul: it followeth, that betwixt the incorporeal Agent, the soul, and those corporeal instruments, the Muscles, there must be some Intermediate instrument, such as is capable of being so transmitted from the Brain, into the Muscles, with the greatest velocity imaginable, and of setting them instantly a-work, according to the determination and direction of the soul. Now, no part of an Animal can be thought capable of such easie and expedite *Mobility*, but the *spirits*, which flow through the body in less than the twinckling of an eye: and therefore, we conclude, that They are the Immediate instrument of the soul, in voluntary motion; according to the assertion of *Galen (in 4. de locis affect cap. 6.)* in these words; *Est in cerebri ventriculis Spiritus, Animæ primum instrumentum, quo & sensum & motum per universas corporis partes Anima transmittit, &c.*

(3) As the Power or Faculty of Seeing doth not reside in the Eye, nor that of Hearing, in the Eare, &c; but is imparted to the organs of sight, and hearing, from the soul, by the mediation of Nervs and Spirits: so likewise is not the Virtue Motive inhærent in the Muscles, but communicated to them upon occasion, from the same soul, and seems to consist wholly in the quick afflux of spirits, as that by which alone they are moved. Which *Galen* also doth not obscurely intimate (*in 1. de mot. Musculor. cap. 8.*) where he saith, *Æquipollens musculorum motus fit, quando neuter tonum Animalem habet auxiliarem;*

6. the conquest of the actiug Muscle, over its Antagonist.

auxiliarem; non æquipollens verò, cum alter solus dominatur: quare necessum est, ut vincat contractio istius musculi, qui ab Animali Faculiate adjuvatur. For, what can be understood by this *Tonus Animalis*, or *Facultas Animalis*, unless it be the distension of the conquering muscle by Animal spirits, sent from the brain, at the pleasure of the Soul?

7. the *swelling* of each Muscle, when it moveth.

(4) What's the reason, that a muscle is never moved, but it becomes more hard and swelling in the middle, than before (as is most evident in both the Masseter and Temporal Muscles, when we chew our meat) unless because it is then filled and distended with a greater gale of spirits, issued out of the store-house of the Brain? For, it seems more reasonable, that this swelling in the body of the Muscle is the Cause of its Contraction; than, on the contrary, that the Contraction should be the cause of the Swelling, as those contend who would have the motion to be performed without the afflux of spirits.

8. the privation of motion in a Muscle, whose *Nerve* is cut off.

(5) If a Nerve be cut asunder, the Muscle into which it was inserted, doth for ever become uncapable of motion; and this, certainly, for no other reason, but because the intercourse of the spirits betwixt the brain and that particular Muscle is wholly destroyed. So that we may well conclude, that the Soul cannot cause voluntary motion, but by the distribution of Animal spirits, through the Nervs, into the Muscles.

The necessity of Animal spirits, as the Immedia

mediate Instrument of the soul, thus appearing; we are next to speculate the Conditions requisite in the Immediate Instrument of the Motion it self: that so we may come to a clear understanding both of the structure and diversity of the Muscles, and at length of the reason of their moving the members, the thing at which our Scrutiny is chiefly levelled.

As for the requisite *Conditions*, therefore, of this last Instrument, we observe,

9. vvhy a Muscle is composed for the most part of *Flesh*.

(1) That in an organ of voluntary Motion is required such a Constitution, as may render it fit to receive the Animal spirits, at the pleasure and command of the soul. Which makes it manifest, that a hard, inflexible, and bony substance is most incompetent to an instrument of motion; for which reason, perhaps, *Galen* adventured to affirme, that any part made hard and stiffe by a thick Cicatrice, becomes unfit for motion: and that it must be such a part, as being soft, rare, spongy, and flexible, and distinguished with multitudes of Fibers, may most easily and readily admit the Gale of spirits flowing into its substance, and be by them filled or distended. Which is the reason, why the substance of the Muscles is for the most part *Fleshy*; than which no part, is more soft, rare, flexible, and distendible: as *Galen* hath observed (*in* 1. *de usu part. cap.* 13.)

10. of a *Nerve*.

(2) Lest the spirits might flow into this flesh, indeterminately or at randome and scatteringly; there ought to be such peculiar vessells or Conduits, which being continued from

the brain or ſpinal marrow, quite home to the Fleſh, into which they are inſerted, may both carry the ſpirits thither, and preſerve them from ſtraying or diſperſing by the way; and by which the Soul, or Regulating Faculty, principally reſiding in the brain, the original of the Nervs, may rule the members, as a Coachman rules his horſes by the rains of his bridles; that we may uſe the ſame compariſon with *Galen*, (1. *de mot. muſculor. cap.* 1.). Now, the *Nervs* being the only parts of the whole body thus qualified, Nature moſt wiſely inſerted one, or more of them, into each Muſcle. So that from this conſtitution of the Nervs, it appears, that they make the ſecond Eſſential part of a Muſcle. Nay, according to ſtrict truth, we may adventure to ſay, that the Fleſh and Nerve are the principal ingredients required to compleat the eſſence of a Muſcle: becauſe there are ſome Muſcles (*viz.* thoſe of the Temples, of the Forehead, of the Eyes, of the Bladder, of the Fundament, &c.) in whoſe bodies are neither Tendons, nor Ligaments to be found, but only Nervs, and Fleſh diſtinguiſhed with various Fibres.

11. *Of a Ligament.* (3) Becauſe in ſome Members, by reaſon of their Gravity, there is a greater reſiſtence to motion, than the Muſculous Fleſh (in reſpect of its ſoftneſs and tenderneſs) is able to overcome; therefore ought there to be an addition of ſome ſtronger and tougher ſubſtance, which being connected or united to the Fleſh of the Muſcle, may both corroborate the ſame, and firmly

firmly conjoyn it to the bones, so as to enable it to move the ponderous member, to whose bones it is fastned. Now, this Nature foresaw, when she furnished some Muscles with *Ligaments*, especially such as were ordained to bear great stress, in moving the greater and more weighty members. Which *Galen* most elegantly expresseth thus; *Ut enim ossa, quæ dearticulantur, exactè simul ligarentur ac continerentur, ne facilè in motibus vehementioribus à sese abrumperentur; Ligamentum, quoad maximè potuit, durum, atque ab injuriis remotissimum efficere oportuit: ut autem ossibus à Musculis tractis promptè obsequeretur, molle rursus esse oportuit, atque ob id ipsum imbecillum. Atqui, forte quidem imbecillo, ac durum molli est contrarium. Quænam igitur fuerit in his Naturæ solertia, quæ corpus invenit, quod commoditatem utramque haberet, idemque ab injuriis tutum esset; ex ipsa Anatome discas, licet, &c. 12. de usu part. cap. 2.*

12. Of a *Tendon*:

(4) Besides the connexion of the Musculous Flesh to the bone, by the mediation of a Ligament, there must be also something to render it prompt, easy and agile in its motion; so as to answer the celerity of the influx of the Spirits, and to fulfill the command of the Soul, as it were in an instant. Which Nature reflecting upon, superadded also a *Tendon*, or Chord, which in respect both of its subtility, and of its tough and strong Contexture, or substance, and also of its connexion to the joynt, doth make the motion more facile and quick, than otherwise it could possibly be; as

as appears in the Muscles of the Hands and Feet, &c.

13. of a *Membrane* investing it:

(5) That these parts named, *viz.* the Flesh, Nerve, Ligament and Tendon, might not be endangered by lying uncovered or confused; therefore hath Nature cloathed the whole Muscle with a proper *Membrane* or *Coat*: which hath these two further Uses; that it causeth the Muscles that are contiguous, to slip up and down easily and without enterfearing each other, and preserves the spirits immitted into the body of the muscle moved, from passing quite through, or dispersing themselves, which they are apt to do, both in respect of their subtility, and of the force of their impulse.

14. and of *Arteries* and *veines*.

(6) And lastly, since this organ of voluntary Motion is to be continually supplied with life, as being *pars corporis vivens*; therefore is it provided of Arteries and veins: those to bring in the vital blood, by whose irradiation all parts of the muscle are made participant of life; and these, to return the blood to the Heart, therein to receive a new impression of life.

15. That a Muscle is the *Immediate Organ* of Motion Voluntary.

Now, seeing that in the whole body of an Animal, there is no other part that hath any the least title to this Description; it is undeniable, that a Muscle is the adæquate or proper and immediate instrument of Motion voluntary: and may conveniently be defined to be, *A part of an Animal, endowed with life, composed of a Nerve and Flesh, and frequently also of a Ligament and Tendon covered with a membrane,*

and

and so framed to be the proxime organ of voluntary Motion. And thus much of the *Structure* of the Muscles.

As for the next Considerable, the *Differences* of the Muscles; they are many, as being desumed from their substance, quantity, figure, situation, original, insertion, Fibres, parts, Use and Action.

In respect of their *Substance*, some Muscles are mostly composed of *Flesh*, as the *Sphincters*, and the Muscles of the *Tongue*: others are mostly *Nervous* and *Membranous*, as the *Fascia lata* abducing the leg, &c. 16. Differences of Muscles, in respect of their substance.

In respect of *Quantity*, which comprehends the 3 dimensions of Longitude, Latitude, and Profundity. Some are *Long*, as the *Musculus rectus* of the Abdomen, the *Thylers* Muscle in the thigh: and others *short*, as the *Musculi Pyramidales* in the bottom of the Abdomen. Some are *Broad*, as the *Oblique* and *Transverse* Muscles of the Abdomen, the *Latissimus dorsi*, *brachium deprimens*, &c: others *Narrow*, as the Muscles of the *Fingers* and *Toes*, &c. Some *Thick*, as the two *Vasti*, or Huge Muscles in the thigh: others *Thin* and slender, as the *Musculus Gracilis* bending the leg, &c. Quantity;

In respect of *Figure*, some are *Triangular*, some *Square*, some *Pentagonal*, some *Pyramidal*, some *Round*, some *Oblong*, and others of other shapes; as the Muscles *Deltoides*, *Rhomboides*, *Scalenus*, *Trapezius*, &c. Figure;

In relation to their *Situation*, some are *Right*, some *Oblique*, some *Transverse* (understand it in Situation;

respect

respect of their Fibres) some *Above*, some *Below*, some on the *right* side, some on the *left*, some *before*, and some *behind*. Where we may note in the general, that oblique muscles serve to oblique motions, Right to exact Flexion, or Extension; and such as are seated within, conduce to Flexion; and such as are posited without, to Extension.

Origination; In respect of their *Original*; some arise from *Bones*, and that either from the *Heads* of them; as most of the greater Muscles; or a little below, or from the *Glene*, some *sinus* or small hollowness in the bone: some only from *one* single bone, some from *two* or *three*: some from *Cartilages* or Gristles, as the Muscles proper to the *Larynx*: some from the *Membrane* enshrouding the Tendons, as the *Musculi vermiculares*: and others from other parts, as the *Sphincters* of the Bladder, and Fundament.

Insertion; Their *Insertion* considered; some are inserted into *Bones*, some into *Cartilages*, as the Muscles of the *Eye-lids*, and of the *Larynx*; others into a *Membrane*, as the Muscles moving the *Eyes*; others into the *skin*, as those of the *Lips*: some arising from divers parts, are inserted only into one; and on the contrary, some arising only from one part, are terminated in many.

Parts; In respect of their *Parts* (by which we must now understand not only such, whereunto as chief ones every Muscle is divided, but those also upon which it is seated); there are various differences. The parts into which each Muscle

is

is commonly divided, are the *Head*, or Beginning; the *Belly*, or Middle; and the *Tail*, or Tendon. Most Muscles have but one Head; yet some have two, others three: whence they are called *Bicipites*, and *Tricipites*. Most have but one Belly, yet some are double-bellied, as the Muscle shutting the *lower jaw*, of the Bone *Hyoïs*, whence they are named *Digastrici*. The Tendons of some are broad and membranous; of others, round; of others, short; of others, long; of some, perforated; of others, intire; of some, single; of others, multiplied. Sometimes you shall find many Muscles ending in one and the same Tendon; as, in the Leg, the *Gemelli* or Twin-Muscles, and the *Solaris*, are united into one Chord. Lastly, from the parts upon which they are seated, they sometimes borrow their names; as the *Crotaphitæ*, or Temple-Muscles; the *Rachitæ*, or *Spinati* of the back; the *Iliaci*, &c.

and Actions.

According to the variety of their particular *Actions*, the Muscles admit of a triple Difference. Whereof the *First* is, that some are *Congeneres*, or *Confederates*, which both conspire to one and the same motion; as when two are Flexors, two Extensors; one possessing the right, the other the left side of the member: and others *Antagonists*, which have motions contrary to those of others; there being scarce any one Muscle, which hath not its Contrary, or Opponent; as to every Flexor is opposed a Tensor; to every Elevator, a Depressor; to every Adductor, an Abductor; excepting only

the two Sphincters, and the Cremasters. The *Confederates* are generally equal in magnitude, number, and strength: the *Antagonists not*, but different, according to the weight of the part to be moved, and the vehemence of the motion. Thus, the Muscles bowing the Head, are only Two; while there are Twelve to lift it up; and those that shut the lower jaw-bone with the upper, are many, but those that open it, are only two; for the weight of heavy bodies doth facilitate their falling downe. The *Second* is, that some Muscles move only Themselves, as the two Sphincters: others somewhat else besides themselves. And the *Last* respecteth the peculiar motions of particular Muscles; whence some are called *Benders*, some *Extensors*; some *Elevators*, others *Depressors*; some *Adductors*, others *Abductors*; some *Rotators*, some *Circumactors*, some *Masseters* or Eaters, some *Cremasters* or Hangers, some *Sphincters* or Constrictors, &c. And thus much concerning the several *Differences* of the Muscles.

17. That the *Reason* of the motion of the Muscles, cannot be explained, without having recourse to *Mathematical* principles.

As to the *Reason* and *Manner* of their Motion (an Argument, as singularly delightfull, so singularly difficult) forasmuch as the Locomotion of the whole body, or any one member of it, being considered *per se*, meerly as Motion, without reflecting upon the end of it, seems to be an effect purely *Mathematicall*, as well because it is a Commensuration of the length of the space betwixt the *Terminus à quo*, *& ad quem*, as because it is a resistence and overpowering of *Gravity*: therefore shall we lay down

down some few *Mathematical principles*, of plain concernment in the explication of it, such as without which our disquisition into the nature of Voluntary Motion vvould be obscure and unsatisfactory.

Fundaments Geometrical.

18. Principles *Geometrical*, of necessary importance toward the understanding thereof.

Proposition, 1.

What are equal to the same, are equal also among themselves: *& è contra.*

Proposition, 2.

All right lines drawn from the Center to the Circumference, are equal.

Proposition, 3.

Two right lines whatsoever, mutually cutting each other, make, at the *vertex*, Angles equal among themselves.

Proposition, 4.

The squares of equal lines, are equal.

Proposition. 5.

A right line, falling upon two right lines æquidistant, or parallels, makes equal Angles.

Proposition, 6.

In Triangles, where the Angles are equal, the sides also are equal and proportional.

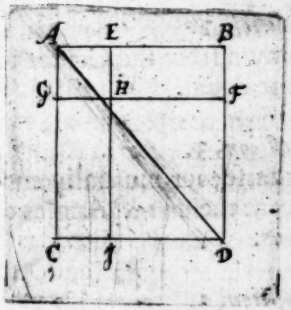
proposition, 7.

In a Triangle, where any one Angle is greater; there the side subtending that Angle, is also greater.

proposition, 8.

In every Parallelogram, the Complements of those Parallelograms, that are about the Diameter, are equal among themselves.

Demonstration.



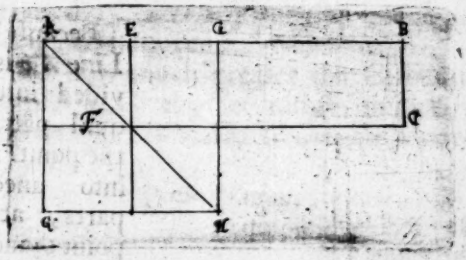
Suppose *A B C D* the Parallelogram; *A D*, the Diameter or Dimetient; and the supplements *H B*, and *H C*. We say, the supplement *H B*. is equal to the Supplement *H C*. because the Parallelogram hath for its Diameter *A D* : and therefore the Triangle *A B D*. is equal to the Triangle *A. C D*. Again, because *A E G H*. hath its diameter *A H*. therefore the Triangle *A G H*. is equal to the Triangle *A E H*. By the same it is demonstrated, that the Triangle *H F D*. is equal to the Triangle *H I D*. Now, since the Triangle *A G H*. is equal to *I D*; and *E H G*. equal to *F D I*: it followes, that the supplement *H B*. is equal to *H C*. Which was to be demonstrated.

Pro-

proposition, 9.

If a streight Line be divided into parts equal and unequal; the Parallelogram, that is contained in the unequal segments of the whole Line given, together with the square of that which is between the segments, will be equal to the square described by the half Line.

Demonstration.



Let the right line be *A B*, divided into equal parts, at the point *C*; and into unequal, at the point *E*. Let from the point *A*, to the proportion of the equal segment, be made a square *A C G H*; and from the point *E*, on the unequal segment, be drawn a parallel line *E F*; and from the point *A*, the Diameter or Dimetient *A H*; and a parallelogram *E F B D*. We say, the Parallelogram *E D*. with the square *F H*. is equal to the square *A H*: which is proved from the Antecedents.

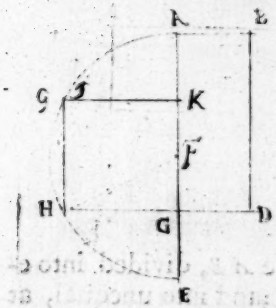
proposition, 10.

To make a Square equal to a Parallelogram given.

Let

Let the Parallelogram be *A B C D*. To which to find a ſquare equal, draw a line from *C* to *E*, to the proportion of *G D*; and divide *A E* into equal parts into the point *F*. from whence make a circle *A G E*; and continue the line *C D* to the point *H*. We ſay, the Line *C H*. is the roote of the ſquare *I K C H*. which is in equal proportion to the Parallelogram *A B C D*.

Demonſtration.



Becauſe the Line *A E* is divided into equal parts at the point *F*. and into unequal parts, at the point *C*; and the Parallelogram contained in the unequal ſegments, together with the ſquare *F C*, is equal to the ſquare *F H*. or *F E*. the equal ſegment, according to the ninth propoſition precedent: it followes, that the Parallelogram *A B C D*. is equal to the ſquare *I K H C*. according to the 47. *propoſition*. 1. *lib. of Euclid*. Which was intended.

Funda-

Fundaments *Architectonical*, out of *Vitruvius*, lib. 10. cap. 8.

19. Principles *Architectonical*, of the same Concerament.

Proposition.

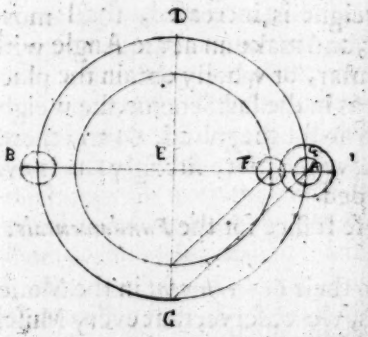
1. In the Center all Gravity ceaseth; so that therein nothing is either Heavy or Light.

2. The power of all Motion is varied, according to the ration of the Center to the Circumference.

3. By how much the more remote or elonged from the Center, any thing is; by so much the swifter is it moved.

4. By how much greater the Circumference of the Circle, so much greater the Diameter, and so much swifter the Motion.

Demonstration.



Let the Center be *E*. from which under the Diameter *E F*. let the weight be placed at *F*. We say, this weight at *F*. doth not rest there, but moveth to its Center, towards *C*. Again, if the same weight be elonged, or removed to *A*; then by reason of its greater

greater distance from *E*, and of the greater Circle; it will be moved towards its Centre *C*, with the greater velocity accordingly.

5. Bodies equal, and under the same Diameter, equally distant from the Center; do cutt a perpendicular Line at right Angles.

Demonstration.

In the former Scheme, let one body be at *B*, and another at *A*. upon the Diameter of the Circle, whose Center is *E*. and neither of them shall move, because their Gravity is equall, in that proportion of the Diameter, and so hasten to the Center *C*. with equal swiftness; but, because they make equal Angles with the perpendicular *D E*.

6. If to one of two equal bodies, placed under the same Diameter, and equally distant from the Center, any weight be superadded; that, whose weight is increased, shall move more strongly, and make an acute Angle with the perpendicular, or wholly obtain the place of the Center: as in the last Scheme, the weight *A* is encreased to the magnitude *G*; and therefore it must move the more strongly; as is evidently concluded.

And let these suffice for the *Fundamentals*.

To come to their *Concernment* in the Motion of the Muscles, we observe, that every Muscle hath a twofold Motion, *viz.* one *Natural*, wherein the Fibers of the muscle spontaneously recontract themselves, after they have been exten-

extended, or restore themselves to their native tenour; by Philosopher named, the motion of *Restitution*, common to all *Tensile* bodies: and this is alwayes from the end, towards the beginning of the Muscle, according to the position of its Fibers: another, *Animal*; wherein the same Fibers are further Contracted, by the forcible and copious influx of Animal spirits, at the command of the soul, in order to the performance of some action intended.

20. That every Muscle hath a Twofold Contraction, viz. *Natural* and *Animal*.

That the Natural Contraction of a Muscle, is not sufficient to voluntary Motion, though we allow every muscle to be made upon the stretch, *i.e.* in an extended position; is manifest from hence, that betwixt each Muscle and its Antagonist, there is an equal power of naturally-moving themselves toward their originals; so that betwixt two Contrary forces, the one drawing one way, the other the clean contrary, the member must be held immoveable; as appears in the 5th. *proposit. Architectonical.* Necessary it is, therefore, to voluntary Motion, that one Muscle over-power the other, not by reason of its spontaneous or Natural Contraction, but of its impressed or Animal; which depends upon the supply of spirits transmitted from the brain, by the Nerves into the Fibers of the acting muscle, and so-distending them, as to cause the whole Muscle to shorten or contract it self. And, that the power of Antagonists is, as we affirme, naturally equal; may be concluded from hence, that if one Muscle be cut off, its Antagonist instantly

21. That the Natural Contraction is not the cause of Voluntary Motion; but only the *Animal*.

 drawes

drawes the member to its side, which before was held in the middle, and as it were equilibrated betwixt them.

22. That in Motion, are Two Terms, one *Fixt*, the other *Moveable*; the last of which is sometimes more, sometimes less remote from the former, according to greater or less resistence of Gravity in the member to be moved, and vehemence of the Motion.

Secondly, we observe; that in all Motion there are *two Terms* to be acknowledged, the *one* is the *point of Rest*, or the Fundament, in which the muscle is firmed or fastned, because all motion is *super aliquo Quiescente*: the *other* is in *parte Mobili*, or insertion of the muscle, from whence the Muscle, by contraction, drawes the member toward it self; and this is sometimes less, sometimes more remote from the Center, or point of rest, according to the less or greater resistence of Gravity in the member to be moved, and according to the less or greater vehemence required to the motion. Which Nature (whose Art is not more admirable in any thing, than in her proportioning the length of the insertion of each muscle, from the Hypomochlion or point of Rest, to the Gravity of the member to be moved) respecting; most ingeniously contrived a way to compensate the slender strength of divers muscles, by inserting them at great distance from the Center of their motion, or that point, about which the member is to be moved. For, since (according to the 1. *proposit. Architectonical*) *there is no motion in the Center*; we may easily understand, why in many muscles, ordained for strong motions, the *Terminus stabilis*, or original, is more remote from the *Terminus Mobilis*, or insertion, than in others framed for motions less strong; *viz.* that by even a small force

force, the muscle (which, considered in its proper bulk, or in any other position, would be insufficient to the effect designed) might elevate a great weight, as we see in the muscles of the Hand, Arme, Thighs, and other parts. For this reason also is it, that in some bones we have certain *prominences*, or Buttings forth in the end, called *Epiphyses*, and *Apophyses*, to which the muscles are fastned. The truth of all which is evinced by the 2d *and* 3d *propos. Architectonical.*

23. No Motion without change of Figure.

These things being thus firmly established, it appears an undeniable truth, that no motion can be made, without changing the Figure of the muscle. For, since equal Angles subtend equal sides, by the 6th *Geometrical Proposition*: it followes necessarily, that in all motion, the Figure of the member moved, is changed.

24. Which is Threefold, respective to the difference of Angles.

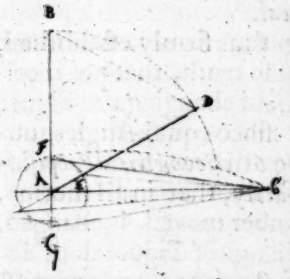
And, because the change of Figure doth depend on the change of Angles; therefore must we admit a threefold Figure, as there are three sorts of Angles, *viz.* (1) a right, in which neither of the two opposite muscles acteth; (2) an obtuse, which being greater than a right, is consequently subtended by a greater side; and (3) an acute, which being less, requires a less subtending line.

25. All motion is made in one of the Two *Extream* Figures; and how, demonstrated.

Now, forasmuch as in the *Middle* Figure, no motion can be made, because then both the opposing Muscles are equally extended: we are to demonstrate, how it is effected in both the *Extreams*. And this, certainly, is done, when one of the acting Muscles is filled or di-

ſtended by the Animal influx, more than its Antagoniſt, whereupon the Figure of the Conquering muſcle is changed; and the Angle of Articulation is made more Acute, or leſs, by that Contraction; and that ſegment, detracted from the line, is in proportion to the ſpace comprehended. For Example.

Demonſtration.



Imagine the Brachium, or upper halfe of the Arme, from the ſhoulder to the elbow, to be *C A*; and the Cubit, or lower half from the elbow to the hand, to be A B: the Muſcle bending the Arme, to be *C F*: and its Antagoniſt extending it, to be *C G*: and the object to be apprehended by the hand, *D*. Now, we ſay, while thoſe two oppoſite Muſcles *G F*. and *C G*. are equally contracted, the Appetite muſt fail of being ſatisfied, *i. e.* the hand cannot be brought to lay hold on the object deſired; becauſe the Figure or Angle of Articulation remains invariable. But, that the hand may be raiſed to the object, it is neceſſary, that Angle ſhould be made more Acute, by contraction of the Muſcle *C F*. in proportion to the motion of the line *B D*: and

becauſe

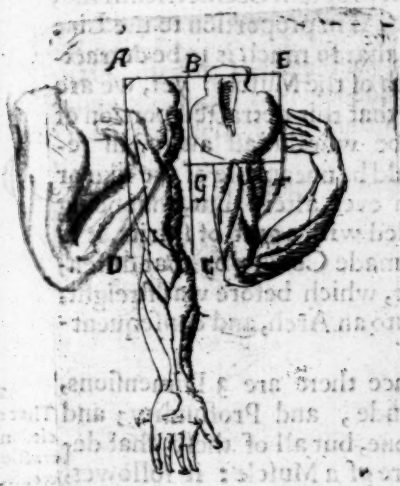
because that Angle is less, therefore is the line subtending it also less, or shorter; according to the 5th and 6th proposit. Geometrical. And, since the Line *E F*. is in proportion to the Line *D B*: it followes that so much is to be detracted from the length of the Muscle: yet, we are not to suppose, that this detracted portion of the Muscle is to be wholly cast away; in regard, then it would be uncapable of the like or any other motion ever after: but, that being plumpt up or filled with a gust of spirits, it is incurvated, or made Convex by that distension; and that line, which before was streight, is now changed into an Arch, and consequently made shorter.

25. That a Muscle, in contraction, is encreased in *Latitude* and *Profundity*, proportionately to its diminution in *Longitude*, demonstrated.

Moreover, since there are 3 Dimensions, Longitude, Latitude, and Profundity; and that it is not any one, but all of these, that determine the Figure of a Muscle: it followes, that all Muscles, while they are contracted, are as much encreased in Thickness and Latitude, as they are diminished in Longitude. Which may be naturally inferred from the importance of the 5. 7. 8. 9. and 10. propositious Geometrical; where a square is found equal to a Parallelogram.

Demon-

Demonstration.



Let the Parallelogram be *A B C D.* representing the Muscle Biceps, of the Arme, as it is extended; and a Square equall thereunto, *B E G F*, representing the same Muscle, as it is contracted. We say, that the Muscle, in its second Figure, or Contraction, hath lost nothing of its bulk, that it had in the first Figure, or Extension: but, because the Square of the muscle, *B E G F.* is equal to the Parallelogramme, *A B C D*; therefore it followes, that the superfice of the muscle is the same, and that the part *G D.* changed in its Latitude, is in proportion to the Line *A D.* which determin's the Local motion.

26. Reflecting upon what hath been said, we soon discover, *why each Muscle generally hath its Antagonist*; there being contrary motions to be performed successively by every member, and it

The Necessity of Antagonist-Muscles.

it being impossible, one and the same Instrument should suffice to both. Now of these Antagonists one doth bend the member, by Contracting it self; and the other by its contraction doth extend it: and both extend each other successively: that which is contracted, doth alwayes act, and that which is extended, doth not act, but suffer, and is transferred with the part moved.

27. How Circular Muscles are Contracted.

But here we are to except some Muscles, which seem so sufficient to the motion of the part into which they are inserted, as to have no need of Antagonists; as all *Circular* muscles, whose motion is easily understood from the mathematical principles premised. For, since a Circular muscle hath circular Fibres, and that all contraction is made *secundum continuitatem lineæ*; it followes, that such muscles shut the part to which they are affixed, by contracting themselves toward their Center; as may be observed in the Sphincters of the Bladder and Fundament, and in the Round muscle of the Eye-lids.

28. Why the Sphincters have no Antagonists.

Onely it may be enquired, Why those *Sphincters* have no Antagonists, as the *Clausor Palpebrarum* seems to have, the *Elevator* opening the eye-lids, as the *Clausor* shuts them? Whereof the Reason certainly is this, that both the Bladder and Fundament are not opened by muscles, but by the quantity of Excrements contained in them, which being pressed or detruded downward by the Diaphragme and muscles of the Abdomen, force open the Sphincters,

Sphincters, by extending their Fibers from the Centre to the Circumference; so that to speak strictly, the excretion of the Urine, and of the Excrements of the belly, are not actions *immediately* voluntary, as the opening of the Eyelids is.

29. Conclusion. And this is all we thought necessary to be said, concerning the Use of the muscles, in *general*, and concerning the admirable Geometry observed by Nature in the Fabrique of them.

Should we extend our discourse, to the accommodation of the Figure and motion of each particular muscle in the whole body, to the Geometrical, and Architectonical principles premised: as we should abuse your Patience, so should we disparage your Capacity of making use of the same Clue for your guidance through the whole Labyrinth of Voluntary Motion, that we have put into your hands for your more easily entering into it. We shall conclude, therefore, with this due acknowledgment; that the *Omniscient Creator hath made all things, as in the Greater World, so also in the Lesser, Man*, in Number, Weight, and Measure.

THE

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19. *Prin-*

FINIS.